THE ENGINEER

A Seven-Day Journal

The Festival of Britain

On Thursday of last week, May 3rd, the Festival of Britain was officially opened by His Majesty The King, in a speech from the steps of St. Paul's Cathedral. Prior to the opening, His Majesty, accompanied by the Queen, Queen Mary, and other Members of the Royal Family, attended a service of dedication in the Cathedral. In his speech, the King made reference to the Great Exhibition in Hyde Park, 100 years ago, saying that its creators were far-sighted men who looked forward to a world in which the advances of art and science would uplift civilisation to enduring peace and prosperity. The Festival of Britain, the King continued, had been planned, like its great predecessor, as a visible sign of national achievement and confidence. Many of the activities and displays would be of lasting value. They would maintain the prestige of our arts and industries abroad by proof of our world-renowned skill in design and craftsmanship, and they would also show how vital a part was played in industry by scientific imagination and research. On Thursday evening, Their Majesties and Members of the Royal Family were present at the opening and dedication of the Royal Festival Hall on the South Bank of the Thames, and on Friday morning they made a tour of the South Bank Exhibition. The Exhibition was opened to the public on Friday afternoon. Other Festival of Britain events last week were the opening, at Southampton Docks, on Thursday of the Exhibition Ship "Campania," by Admiral Sir Arthur Power, Commander-in-Chief, Portsmouth, and the opening, on Saturday, at Manchester, of the Land Travelling Exhibition, by Mr. R. R. Stokes, the Lord Privy Seal. The Festival Exhibition of Science, at South Kensington, was opened on Friday by Lord Addison, Lord President of the Council.

Royal Aeronautical Society's Garden Party

The eleventh annual garden party of the Royal Aeronautical Society was held at White Waltham aerodrome, near Maidenhead, on Sunday last, May 6th, and was attended by 3500 members and guests. On this occasion the President, Major G. P. Bulman, and Mrs. Bulman, arrived by a Westland Sikorsky S.51 helicopter shortly before the start of the flying programme. During the first part of the afternoon the guests were able to examine an interesting display of early historical aircraft, lent from several collections, notably the Shuttleworth collection and the aeronautical collection of the Science Museum. The Handley Page "Gugnunc" was included in this exhibition, an aircraft designed in 1929 for the Guggenheim International Safe Aircraft Competition, which specified a maximum landing speed of 35 m.p.h. and a top speed of 110 m.p.h. The "Gugnunc" was fitted with high-pressure interconnected slots and flaps and comfortably complied with the regulations. The Sopwith "Triplane," fitted with a 100 h.p. "Clerget" rotary engine, and the Westland-Hill "Pterodactyl," a tailless pusher type aircraft with a 33 h.p. Bristol "Cherub" horizontal engine, were amongst others in the display. In spite of heavy broken stratus cloud associated with cumulonimbus, the flying programme was not interrupted by rain, and there were full aerobatic displays given by many veteran aircraft. Particularly interesting was that given by Neville Duke in a 1930 Hawker "Tomtit" fitted with a 150 h.p. Armstrong Siddeley "Mongoose" engine; the "falling leaf" manœuvre was executed from a 1000ft down to about 300ft. The loudest display was that of the B.A.C. "Drone," which had a 32 h.p. Corden Ford engine, the least noisy being the 1916 Sopwith "Pup," fitted with a 80 h.p. Le Rhone rotary engine. An "R" type observation balloon and six Cody lifting kites also made ascents. Among other historic aircraft were the Bristol F.2B fighter with a R.R. "Falcon" engine, flown by A. J. Pegg, and the de Havilland "Dragon" aircraft, the forerunner of the "Rapide" machine.

The James Watt International Medal

At a general meeting of the Institution of Mechanical Engineers, held in London last Friday evening, the President, Mr. A. C. Hartley, presented the James Watt International Medal for 1951 to Dr. Hans Henrik Blache, of Denmark, for his contributions to the advancement of mechanical engineering, and particularly for his pioneer work in the development of the large marine diesel engine. An award of the medal is made every two years—to commemorate the birth of James Watt—to an engineer of any nationality. It is the highest award that the Institution can bestow and a mechanical engineer can receive. Dr. Blache, who was born in Copenhagen in 1874, is a consulting engineer, and for the greater part of his career has been closely associated with Burmeister and Wain, Ltd., which firm he first joined over fifty years ago. In 1912 he was appointed chief engineer of Burmeister and Wain, Ltd., to take charge of all engineering designs within the company, and from that time has been intimately connected with the development of the marine diesel engine. For a few years prior to the second World War Dr. Blache was on the staff of Harland and Wolff, Ltd., Belfast, returning to Denmark in 1939 to resume his work there. He was awarded the degree of doctor technisis h.c. by the Royal Technical University of Denmark in 1929. The citation accompanying the medal said that "quite apart from his personal contribution in the technical field, Dr. Blache has been an inspiring leader, drawing out the best from those under him and effectively co-ordinating the application of technical knowledge whatever its source might be." Count Eduard Reventlow, Danish Ambassador to the Court of St. James, was present at the meeting, and spoke of Dr. Blache's achievements. Following the presentation, Dr. Blache delivered a James Clayton Lecture on "Stages in the Design of the Large Burmeister and Wain Marine Diesel Engine."

International Traffic Arteries in Europe

Six more countries—Austria, Italy, Norway, Switzerland, Turkey and Yugoslavia—have announced their intention of signing the United Nations' declaration on the construction of main international traffic arteries in Europe. The announcement was made at a meeting, recently concluded in Geneva, of the Transport Sub-Committee of the United Nations' Economic Commission for Europe. The declaration was signed last September by the United Kingdom, Belgium, France, Luxembourg and the Netherlands. In signing, countries certify their intention to construct or reconstruct, so far as means are available, roads within their territory which form their part of the "E" network, making them correspond to specific standards agreed upon by the Economic Commission for Europe as being required for main international traffic. The "E" network of international road traffic arteries includes approximately 33,600 miles of existing or planned routes in twenty-one European countries. During the Road Transport Sub-Committee's recent session, delegates from fourteen countries outlined major principles which they wish to see embodied in an international agreement on economic and technical regulations to improve international commercial road transport in Europe and to encourage its development. The Government representatives attending the meeting also suggested the drafting of an international convention to eliminate the levy of fiscal charges by more than one state on commercial lorries and buses engaged in international transport.

Scottish Building Research Laboratory

An advisory committee for the Scottish Laboratory of the Building Research Station has been set up under the chairmanship of Mr. Lockhart W. Hutson, F.R.I.B.A. The other members of the committee are Mr. J. Banks, M.I.C.E., Mr. J. Austen Bent, A.R.I.B.A., Mr. C. Brownlie, Lieut.-Colonel Alexander Cullen, F.R.I.B.A., Mr. John Lawrence, Mr. G. L. Orchard, F.R.I.C.S., and Mr. W. H. Wylie. All of them serve in a personal capacity and not by virtue of any position they may hold in public life or industry. The committee's task will be to ensure that the work of the laboratory serves the special requirements of Scotland and also help to link it closely with the Scottish building industry. The laboratory was set up at Thorntonhall, near Glasgow, in the latter half of 1949 to extend the scope of building research by studying conditions, materials and practice in Scotland and the North of England. It is responsible for making the knowledge and facilities of the Building Research Station more readily accessible to the building industry in those areas. Its programme of research includes the study of Scottish building materials such as clay and concrete bricks, limes, building sands and aggregates for concrete. The Scottish climate and its effect on building materials and forms of construction are also being studied.

The Cunard Company's Progress

In a statement accompanying the annual report of the Cunard Steam Ship Company, Ltd., Mr. F. A. Bates, the chairman, has referred to the company's historical background as a mark of its present progress. Progress, the statement said, meant change, and that implied renewal from the reserves of experience. Mr. Bates went on to commend the work of the staffs afloat and ashore and suggested that a fitting motto would be "teamwork around the clock, the year and the globe." He maintained that enterprise and the urge for adventure still remained strong in spite of restrictions, and looked forward to the day when hampering economic theories would be buried in the grave of frustration with a headstone inscribed "Better sail in a ship than live in a sheepfold." Referring to the devaluation load now on the company's back, Mr. Bates said that the long-term effect was the reduction in the purchasing power of existing reserves set aside for fleet replacement. He warned that the amount earmarked for depreciation was completely unrealistic and required to be multiplied several times over to meet the real cost of ship replacement at current prices. Furthermore, this high fleet renewal charge was aggravated by inflationary taxation. He also drew attention to the fact that the increased operating surplus brought no benefit to the company and even added to the burden of taxation, so that there appeared the depressing possibility of being involved in the law of diminishing returns.

The South Bank Exhibition

No. II—ROAD AND RAIL TRANSPORT

(*Continued from page 565, May 4th*)

A COMPREHENSIVE range of the motor-cars, commercial vehicles, motor-cycles and bicycles made in this country can be seen in the "Transport and Communications" pavilion. During the period the Festival is open these exhibits will be changed from time to time to show the products of many different manufacturers.

Typical designs of heavy and medium commercial vehicles can be seen on the terrace of the pavilion, and on or near a ramp leading from the ground to the first floor private motor-cars will be exhibited. These private cars will include a typical luxury limousine, a low-priced, mass-produced car, a light and medium large saloon, a convertible and a sports car. A fifty-year-old Lancaster car, which is being shown together with a sectionalised car of advanced modern conception, illustrates the advances made in design and construction during the past half century.

The history of the mechanically-propelled vehicle is traced by a series of models, and some noteworthy record-breaking cars and the first gas turbine propelled car developed by the Rover Company are included in the exhibits. As an interesting contrast to contemporary modern road transport vehicles, a typical bus of 1910 is exhibited, and numerous scale models are used to give an historical account of public transport.

Aeronautics

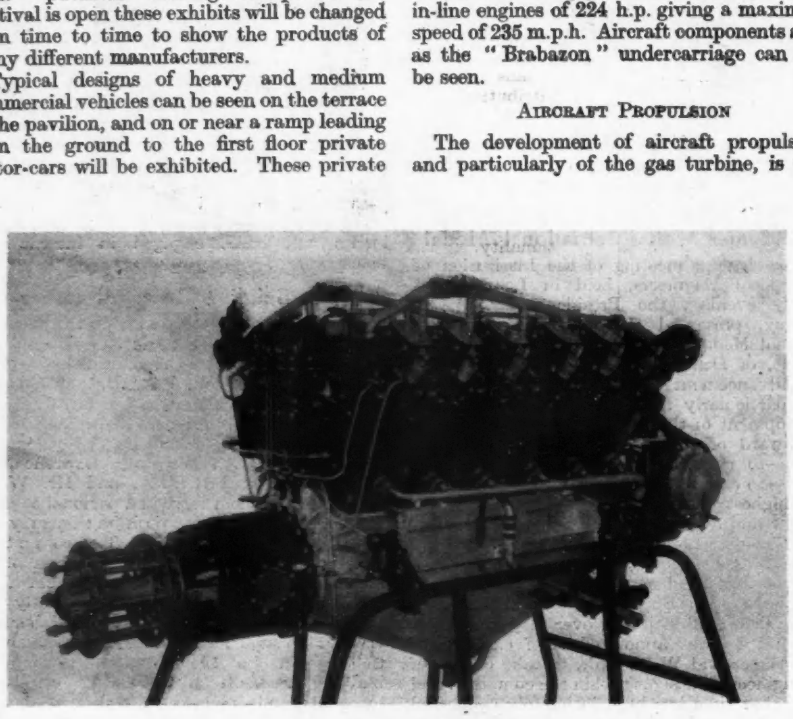
Complementary to the road transport vehicles are a number of different makes and types of industrial trucks which have been developed during more recent years for the mechanical handling and transport of goods.

Forming part of the display in this pavilion depicting Britain's contribution to world transport is the section on the first floor gallery concerned with the growth of aeronautics in this country. In this display there is presented, with the aid of models and photographs, the story of the early development of flight, continuing with the establishment of the world's air routes and speed records in the era between the two World Wars, and concluding with scale models of contemporary aircraft. Suspended in the well of the pavilion is one of the 1931, 407 m.p.h. Schneider Trophy seaplanes, which was fitted with a Rolls Royce "R" engine of 2300 h.p.; and the actual de Havilland "Comet" machine in which Scott and Campbell-Black flew to Australia in less than three days. It is fitted with 2 D.H. "Gipsy Six" air-cooled inverted in-line engines of 224 h.p. giving a maximum speed of 235 m.p.h. Aircraft components such as the "Brabazon" undercarriage can also be seen.

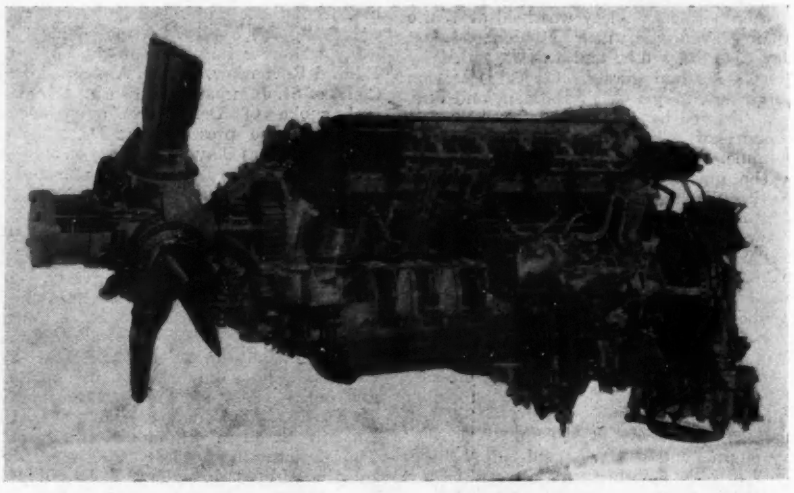
Aircraft Propulsion

The development of aircraft propulsion, and particularly of the gas turbine, is well shown by working and sectional engines from the past and present ranges of some of Britain's leading aero-engine manufacturers.

The first significant contribution made by the Rolls Royce Company in the field of aircraft propulsion is represented by a model of the 250 h.p. "Falcon" engine, which is illustrated herewith. The "Falcon" engine, which was designed for fighter aircraft of the first World War, first flew in 1915 and achieved a reputation comparable with that of the "Merlin" series of engines of the last war. Over 2000 units were produced which were mostly fitted to the Bristol Fighter machine, itself one of the most successful combat machines produced at that time. It had a top speed of 125 m.p.h. and included amongst its armament a Vickers machine gun firing with the aid of synchroniser gear through the airscrew disc. A slightly larger version was the "Eagle" engine of 360 h.p., which, in June, 1919, was fitted to the Vickers "Vimy" aeroplane for the first 16-hr non-stop crossing of the Atlantic. It is worthy of note that the "Falcon" engine has remained the standard basic type of the Rolls Royce series of engines right up to the present day. It was a liquid-cooled, 60 deg. vee engine of twelve cylinders mounted in two banks of six. Following the development of such engines as the "Condor" series of 670 h.p., the "Kestrel" series of 490 h.p. to 575 h.p., and the "Buzzard" of 825 h.p., there was finally evolved the "Merlin" series, which was later to play so important a part in the last war. The "Merlin III" engine was the first engine to power the "Spitfire" and the first engine in the 1000 h.p. class to be mass produced. Later and more powerful versions of the "Merlin" differed mainly in the nature of their supercharging equipment, and in the manner of fuel injection. The particular version displayed and illustrated herewith is one of the Mark 60 series, developing 1760 b.h.p. It was the first "Merlin" engine series to incorporate a two-stage, two-speed supercharger arranged with two centrifugal impellers mounted in series and employing intercooling, final cooling and diffusion. Air is compressed in the first-stage impeller, and diffused and cooled in ducting leading to the eye of the second-stage impeller. It is again compressed and finally diffused, cooling being effected by a water-cooled radiator placed in the induction circuit. At 40,000ft a pressure ratio of 6 : 1 can be maintained in the supercharger and the power developed is twice that of the "Merlin III" engine under these conditions. An R.R. Bendix-Stromberg injection type up-draught carburetter is fitted to several marks and later versions employ direct fuel injection into the eye of the supercharger impeller.



ROLLS ROYCE "FALCON" ENGINE



ROLLS ROYCE "MERLIN MK60" ENGINE

Basically, the vee engine remains unchanged and it has twelve cylinders arranged in two banks, providing a total capacity of 27 litres. The cylinder bore is 5·40in, stroke 6in, compression ratio 6 : 1, and the net dry weight is 1600 lb. The cooling medium employed is a mixture of water

with 30 per cent glycol under pressure. Direct spur gears provide a reduction of 0·42 : 1.

The "Merlin" series was used extensively in British fighter aircraft during the last war, and was fitted to many marks of the "Lancaster" "Lincoln," and "Halifax" heavy bombers. It was fitted also to the Bristol "Beaufighter II," but its most fortunate association was probably with the de Havilland "Mosquito" machine. It has since been developed for civil aviation and, as such is fitted to "North Star" aircraft operated by Trans-Canada Air Lines, "Argonauts," operated by British Overseas Airways Corporation, and the "Empress" class airliner used by Canadian Pacific Airways.

Rolls Royce, Ltd., started to take an interest in jet propulsion units in 1938. By June, 1941, the company had developed a compressor test plant and during that year was asked by the Ministry of Supply to undertake the production of the Whittle engine in conjunction with Power Jets, Ltd. The first Rolls Royce engine passed the 100-hour type test in 1943. It was 43in in diameter and for a net weight of 850 lb produced a static thrust of 1700 lb. Delivery of this engine to the R.A.F. commenced in 1944 and it was known as the "Welland." Rolls Royce modified this engine and was able to raise the thrust to 2000 lb. In November, 1943, it passed the 100-hour type test and became the first of the "Derwent" series of turbo-jet engines. The series "5" engine which the company is displaying has been developed to give twice the thrust of the Mark I and is rated at 3500 lb thrust.

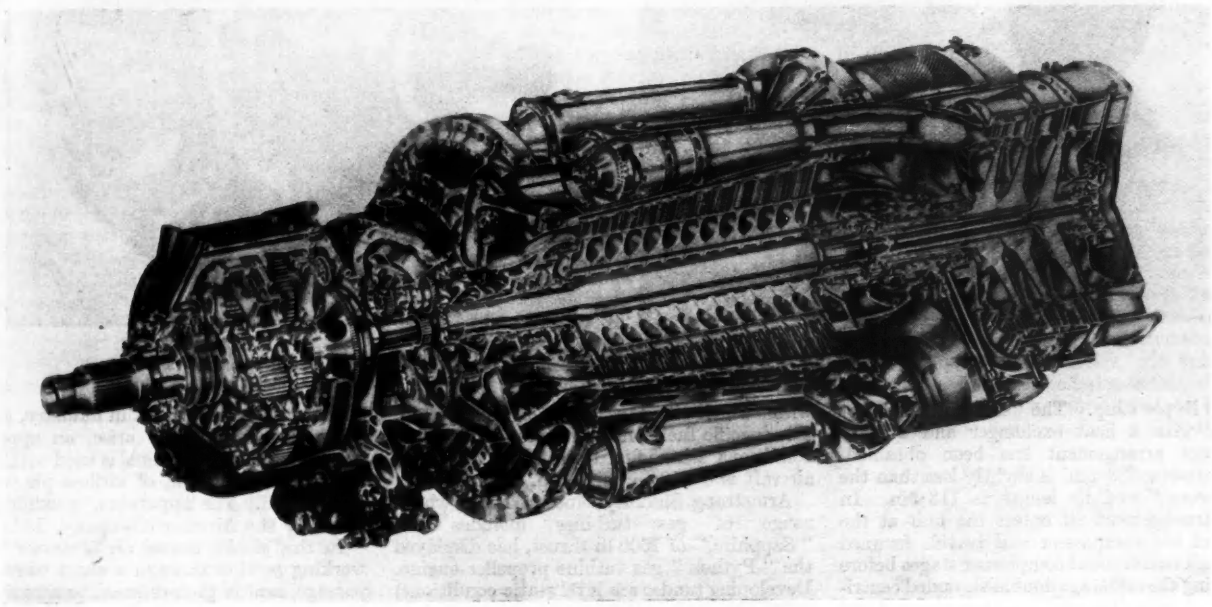
It was special engines of this series which enabled the "Meteor 4" to gain the world speed record for Great Britain in 1945 at a speed of 606 m.p.h.

The "Derwent" engine shown is a simple turbo-jet containing a double-sided centrifugal compressor and a single-stage turbine on the same shaft. Nine combustion chambers are arranged round the engine, and an exhaust unit and jet pipe are fitted behind the turbine. Air enters the compressor by twin radial intakes and is delivered under pressure into the combustion chambers, where it is continuously burnt with fuel. The gas then passes from an annular nozzle containing a ring of guide vanes to the turbine blades, which drive the compressor. After leaving the turbine the gas passes into the jet pipe via the exhaust unit. "Derwent 5" and "8" engines power the "Meteor 4" and "8," which are in squadron service with the R.A.F., as well as with the Air Forces of Western Europe, the Middle East and South America. In 1949 a test schedule was laid down in which the "Derwent 5" engine was to run continuously for 100 hours under combat conditions. The test consisted of twenty five-hour cycles running at a speed of 14,700 r.p.m., and a jet pipe temperature of 680 deg. Cent. It is believed that this engine was the first unit to endure this test successfully; on completion it was still developing 3600 lb jet thrust.

The Rolls Royce "Dart" is a turbo-propeller engine with a maximum power rating of 1400 s.h.p., plus 295 lb static thrust. The design of the engine was started in early 1945 and the first engine ran in the summer of 1946. This engine has a two-stage centrifugal compressor, seven combustion chambers and a two-stage axial-flow turbine. Installed in the prototype "Viscount" airliner, "Darts" rated at 1250 h.p. were the first turbo-propeller engines to operate on a scheduled air service. This was during the summer of 1950, when British European Airways, to gain flight experience with the engines, operated the "Viscount" on a twice-daily service between London and Paris. The 1400 h.p. engines now under development will be fitted to the "Viscount 700" machine on order for British European Airways. The "Dart" has run for over 6000 hours on the test bed and during hangar development running. The total flying time is nearly 3000 hours, including 2000 engine-hours whilst installed in the "Viscount."

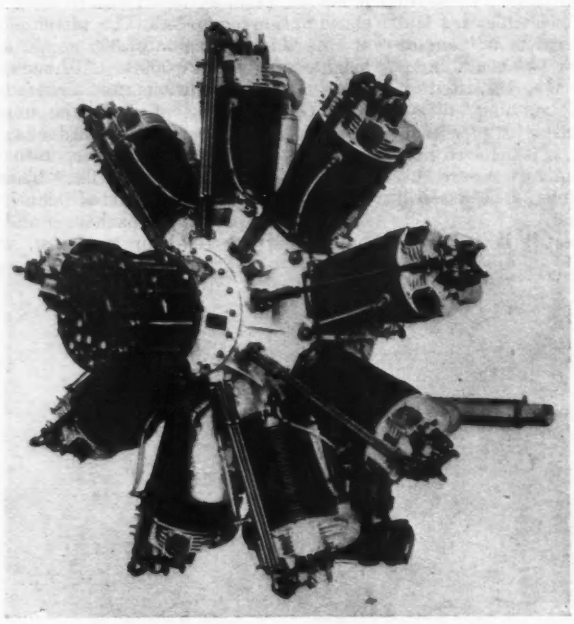
Although the Bristol Aeroplane Company had been principally associated with the development of the sleeve valve radial engine before the war, it has long been aware of the low fuel consumption properties inherent with the composite engine, which has, apart from the normal reciprocating parts, an exhaust-driven turbo-supercharger. This company had, in fact, modified a Bristol "Jupiter" engine to incorporate an exhaust-driven supercharger as far back as 1923, and by the outbreak of the last war it was beginning to consider the possibilities of employing a piston engine working in conjunction with a gas turbine. However, with the advent of the gas turbine as a prime mover, the Bristol company set itself as a primary objective the design of a propeller gas turbine, which was to have a fuel consumption comparable to piston engines at speeds in the region of 300 m.p.h. and at heights of about 20,000ft. Although these were modest conditions for air transport, from considerations of maximum unit efficiency they are particularly arduous: consequently it was decided to incorporate within the cycle a heat exchanger. The "Theseus" in its original form was the first aeronautical gas turbine to employ a heat exchanger and later, on passing the 100-hour type test, was to hold also the Certificate No. 1 for gas turbines. The "Theseus" had two further distinguishing details in its arrangement. The compressor uses nine stages of axial blading, but uses for the last stage a centrifugal impeller of somewhat larger diameter. This arrangement aims to include the higher efficiencies of the axial compressor with the greater flexibility characteristic of the centrifugal compressor over a less critical operating range. It employs also a free power turbine connected directly to the propeller reduction gear and is mechanically independent of the first two stages, which are mounted on a single disc and drive the compressor and auxiliaries. The "Theseus" was however modified and the heat exchanger removed. The engine has an overall diameter of 54in and length of 81·85in. Its net dry weight is 2205 lb and the power developed at sea level (static) is 2220 h.p. plus 825 lb jet thrust. The fuel consumption is 272 Imperial gallons per hour.

The Bristol company had under development at that time a more powerful engine of somewhat different design, the "Proteus," which first ran in 1947. It was intended for use as a "buried" wing installation and is now being fitted in coupled pairs to the "Brabazon II" airliner and the Saunders-Roe SR/45 long-range flying-boat. The "Proteus," which is illustrated, is designed for cruising speeds in the 300 to 400 m.p.h.

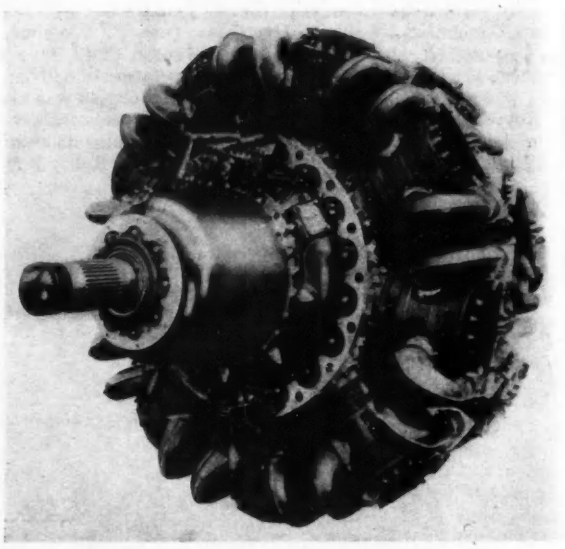


THE BRISTOL "PROTEUS" PROPELLER TURBINE

range and at altitudes from 30,000ft to 40,000ft. At a speed of 350 m.p.h. and a height of 35,000ft the turbine develops 1260 s.h.p., with 560 lb jet thrust, whilst under sea-level static conditions, 3200 s.h.p. is developed, plus 800 lb thrust. The specific fuel consumption at 35,000ft (350 m.p.h.) is 0·510 lb per s.h.p. The "Proteus" was not fitted with a heat exchanger and a very compact arrangement has been obtained. Its diameter (38·5in) is slightly less than the "Theseus" and its length is 113·5in. In this arrangement air enters the unit at the rear of the compressor and travels forward through twelve axial compressor stages before entering the last stage double-shrouded centrifugal impeller. The airflow is then reversed and enters the eight combustion chambers disposed around the compressor casing. Like the "Theseus," engine it employs a free turbine and it has a maximum speed of 10,700 r.p.m. The compressor and auxilaries are driven by a two-stage turbine which has a maximum speed of 10,000 r.p.m. The net dry weight is 2900 lb. A compound epicyclic train provides a reduction of 11·9 : 1 between the power turbine and the propeller shaft. We also illustrate the "Jupiter" radial piston engine, which, like the "Mercury" and "Pegasus" engines, was developed from the "Cosmos" 300 h.p. to 350 h.p. engine, which was designed shortly after the first World War. These engines employ nine air-cooled cylinders and the later series of "Mercury" and "Pegasus" units were geared and supercharged. The "Perseus" series were the first radial engines to be fitted with sleeve valves, which the Bristol company developed for this particular type of engine. Sleeve valves had only previously been used in automobile practice. Following the 495 h.p. to 515 h.p. "Perseus" came the "Hercules" series of fourteen-cylinder, two-row sleeve-valve engines, marks of which now develop over 2000 h.p. The "Hercules" engine was fitted to all but one mark of the ubiquitous Bristol "Beaufighter" and to several medium and heavy bombers in service during the war. The most recent radial engine to be produced is the "Centaurus" two-row sleeve-valve unit of 3270 cubic inch capacity. It is similar in general design to the "Hercules" engine, but has eighteen cylinders, (as opposed to the "Hercules" fourteen) and an extra half-inch stroke. The "Centaurus" was first type-tested in 1940 and was widely used in fighter bombers towards the end of the war, and is now used in civil aircraft. The "Centaurus 18," which is illustrated, has provision for water-methanol injection, with which it can develop 2810 b.h.p. The specific fuel consumption under cruising conditions when fitted to the "Brigand" aircraft is 0·418 lb per b.h.p. per hour.

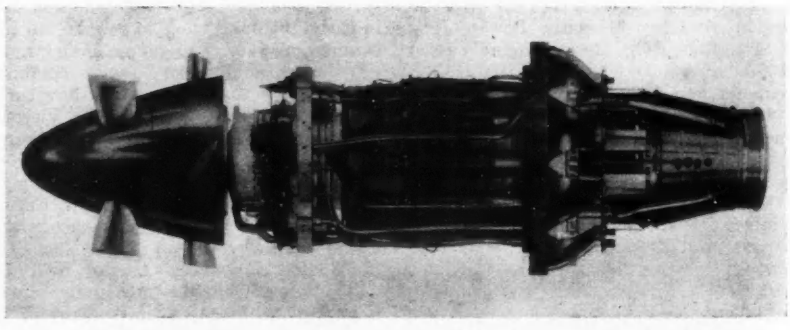


THE BRISTOL "JUPITER IV"



THE BRISTOL "CENTAURUS 18"

Armstrong Siddeley Motors, Ltd., whose range of gas turbines includes the "Sapphire," of 7600 lb thrust, has displayed the "Python" gas turbine propeller engine. Developing (under sea level static conditions) 3670 s.h.p. plus 1150 lb thrust, equivalent to 4110 s.h.p., it is the most powerful British propeller jet turbine of which details have been released. This company began work on the gas turbine in 1941 and has now five gas turbines in production. All these units employ the axial compressor and incorporate a vaporising combustion system which this company developed; in some cases, as in the "Sapphire" an annular combustion chamber is used. The "Python" was the first production gas turbine to be made by this company, and it passed its type test in 1945. It has a fourteen-stage axial compressor, giving a compression ratio of 5 : 1 and a two-stage turbine. Eleven combustion chambers are disposed around the compressor casing. Like the Bristol "Proteus" it is a reverse-flow engine and the forward facing air intake is placed at the rear of the compressor, so effectively shortening the length of the unit. The "Python" is fitted to the "Wyvern" naval "strike" fighter.



THE ARMSTRONG SIDDELEY "PYTHON" GAS TURBINE

OTHER EXHIBITS

In places where aerodynamic instruction is undertaken and where, in industry, certain other airflow problems arise, an apparatus known as the smoke tunnel is used with which a visual presentation of airflow phenomena is obtained. The apparatus, as exhibited, is made by the Airscrew Company, Ltd.

In this smoke tunnel air is drawn to the working section through a short converging passage, and is then diffused to atmosphere. The fan motor, situated at the end of the expanding diffuser, is a ½ h.p. single-phase commutator motor fitted with a two-bladed fan, and air speeds ranging from 3ft to 40ft per second can be obtained in the working section. A fine-wire gauze placed at the mouth of the tunnel helps to stabilise the air flow. Paraffin is vaporised in a unit originally devised by the Aerodynamics Department of the N.P.L., and the vapour is led from this apparatus to a comb of fine tubes placed just ahead of the working section.

The smoke filaments are evenly spaced and take up the direction of the airstream.

The working section is 18in square and sufficiently long to permit development of the wake formations. Because of the design of this particular working section, three dimensional flow patterns can be observed. Such observations are made through a glass panel, forming one wall of the working section, which is illuminated from above and below. When used as a smoke tunnel the maximum wind speed is 10ft per second. The tunnel, however, is also fitted with a two-component balance—lift and drag forces—and with the wire gauze removed quantitative work can be undertaken with speeds up to 40ft per second.

(To be continued)

Historic Development of the Theory of the Flow of Water in Canals and Rivers*

By SERGE LELIAVSKY BEY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. V—*(Continued from page 567, May 4th)*

THE hydraulic effect of the shape of the profile of a closed conduit in the particular case of laminar flow has been analysed theoretically by Boussinesq.[52]

In addition to the formula for circular pipes, which was already known in 1839,[53] he gave solutions for laminar flow in rectangular, elliptical and triangular conduits. Should the hydraulic radius be taken as basis for comparison, the following correction coefficients must be introduced in the formulæ for the friction coefficient f for various pipe sections (the circular pipe being taken as unity) :—

Shape	Breadth/Length	Coefficient
Ellipse	0·7	1·01
Ellipse	0·5	1·06
Ellipse	0·3	1·14
Ellipse	0·2	1·19
Ellipse	0·1	1·22
Rectangle	1·0	1·50
Rectangle	0·1	1·33
Rectangle	0·2	1·19
Rectangle	0·25	1·14
Rectangle	0·333	1·08
Rectangle	0·5	0·98
Square	1·0	0·89
Triangle	Equilateral	0·83

Boussinesq's analysis is fully confirmed by experimental research work. It follows, therefore, that for laminar flow the hydraulic radius cannot serve to define the hydraulic efficiency of a section, unless the corresponding value of the correction coefficient is known; which, of course, reduces the utility of this parameter to nothing.

The case is not as bad for turbulent flow, but here again the application of m does not appear to be entirely unconditional. From the experiments of Saph and Schoder,[54] Blasius[55] deduced that the friction factor f was inversely proportional to the square root of the square root of Reynolds number. This result was applicable to circular pipes only. Von Mises[56] found theoretically that, for values of Reynolds number above 1350, the same formula must apply to other profiles also, with the hydraulic radius as the significant factor and basis of comparison, subject to the proviso that the shear at the boundary must be proportional to the square of the velocity.

Von Mises' conclusions are usually supposed[57] to have been verified (and confirmed) experimentally by Schiller.[58] Up to a point this is certainly true. For triangular and rectangular sections the coincidence of the results is indeed very satisfactory, but for

FIG. 22

the star-shaped profile shown in Fig. 22 the agreement between theory and experiment is far less precise.

In fact, the experimental and theoretical curves in the relevant diagram appear to

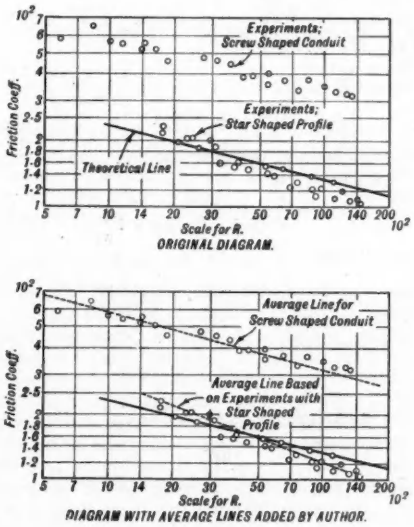

Friction Coeff.
Experiments; Screw Shaped Conduit
Experiments; Star Shaped Profile
Theoretical Line
Scale for R.
ORIGINAL DIAGRAM.
Average Line for Screw Shaped Conduit
Average Line Based on Experiments with Star Shaped Profile
Scale for R.
DIAGRAM WITH AVERAGE LINES ADDED BY AUTHOR.

FIG. 23

intersect each other at a slight angle (see Fig. 23).

The screw-shaped conduit shown in Fig. 24 does not support the theory at all.

On the whole, while the bulk of his experiments appears to substantiate the use of the hydraulic radius in discharge formulæ, Schiller, nevertheless, says[59] : "That this is not the complete law—as is also seen from the experimental departures from the theory—follows from the possibility of introducing another dimensionless term, namely, p^2/a.[60] According to the results of the experiments, the effect of this second parameter does not appear to be excessively great; at any rate, less than the full range of its variation for sections experimented with, that is: circular pipe 12·55; square 16; triangle 20·8; star 21·7; rectangle (2 : 7) 23·2."

In so far as it qualifies the universal use of the hydraulic radius, this conclusion is strongly supported by the experiments carried out seven years later by Caldwell.[61]

FIG. 24

In this case a circular pipe was provided with an inner core, which was maintained, at will, in various positions starting at the centre of the pipe, as in Fig. 25*a*, and ending with the extreme case when it touched the pipe, as in Fig. 25*b*. Apart from the circular core, other shapes were also experimented with, as shown in the same drawing.

It will be realised that whatever the eccentricity the hydraulic radius remains the same. Hence, theoretically, the velocities and discharges must be independent of these eccentricities. This was proved to be by no means the case; in fact, a formula was

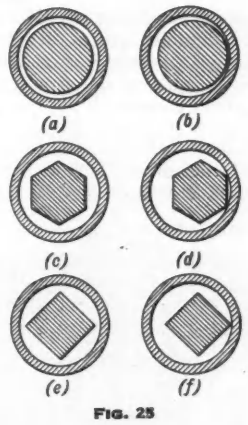


FIG. 25

produced showing that the hydraulic radius m must be replaced by

$$\frac{m}{1-0\cdot38e/m}$$

where e is the eccentricity of the core. This formula, of course, has only a limited application, within the range of the sections and conditions covered by these experiments. It is, nevertheless, of considerable interest, for it upsets another pre-established superstition, viz., the claim for the hydraulic radius as a general and complete representation of the flow area. This does not mean that Von Mises' analysis is at fault, but only that his assumptions are not justified in practice. And, since those assumptions are even less likely to be universally correct in open channel flow, than in pipes, there

* The opinions expressed in this article are those of the author and do not necessarily represent those of the Egyptian Ministry of Public Works.

[52] "Mémoire sur l'influence des frottements," Journal de math. pur et appl.," 1868.

[53] Hagen, "Uber die Bewegung des Wassers in engen zylindrischen Rohren," Berlin, 1839.

[54] A. V. Saph and E. H. Schoder, "An Experimental . . ." "Trans.," Am. Soc. C.E., 1903.

[55] H. Blasius, "Das Aehnlichkeitgesetz . . ." Mitteil. ub. Forsch., Verein deutsch. Ing., 131, 1913.

[56] Von Mises, Tech. Hydrodynamic, Leipzig, 1914.

[57] Cf., Davies and White, "A Review of Flow in Pipes and Channels," *Engineering*, August 2, 1929, page 132.

[58] L. Schiller, "Uber den Stromungwiderstand . . .", "Zeitschrift für angewandte Mathematik . . ." 1, 1923.

[59] Free translation.

[60] Our notation, in which p=perimeter, and a=area.

[61] J. Caldwell, "The Hydraulic Mean Depth as a Basis for Comparison in the Flow of Fluids in Pipes," *Journal* of Royal Technical College, Glasgow, January, 1930.

are still more reasons for believing that the estimate of the hydraulic efficiency of a canal profile may possibly be derived in future from a more sound basis than the hydraulic radius. Here, again, there is a wide field for further experiment.

Another group of modern research tendencies in connection with discharge formulæ centres around the interrelation between the coefficient C and the concept of the "stationary layer." This is by no means a new problem, but its modern treatment differs fundamentally from that of the early nineteenth century.

Recent research shows that, indeed, there is such a "laminar boundary layer" between the region of turbulent flow and the solid material of the trough. The existence of this layer is explained by the stabilising effect which a solid and very smooth boundary produces on the flow of water. There are two factors present here whose respective influences on the flow are diametrically opposite: (*a*) the disturbing action of the turbulence in the upper part of the stream and (*b*) the stabilising action of the smooth and rigid surface of the bed. Thus, the further from the bed the greater the tendency to change from laminar to turbulent flow. The analysis of the mechanical conditions of the case brings forward the importance of a new constant, "the stability parameter" ψ, whose symbolical expression is

$$\psi=\frac{y^3\rho dv/dy}{\mu}$$

The sketches in Fig. 26 illustrate the physical interpretation of this formula. The tendency to change from the gradually varying, sliding movement of the laminar flow into the irregular regimen of the turbulent flow must obviously depend on the rate of change of the velocity $\frac{dv}{dy}$; whilst the opposing, stabilising effect of the boundary must diminish with a certain power of the ordinate y (distance from the boundary). In the above equation this power is assumed to be 2, which is confirmed by precise observations.

It follows that the tendency towards altering the nature of the flow, from laminar to turbulent, is proportional to the product $y^2\frac{dv}{dy}$, which attains a maximum at a certain critical distance from the boundary, as shown in Fig. 26.[62]

Reverting now to the Prandtl-Karman "scala" for a very smooth boundary, the assumption is made that the change from

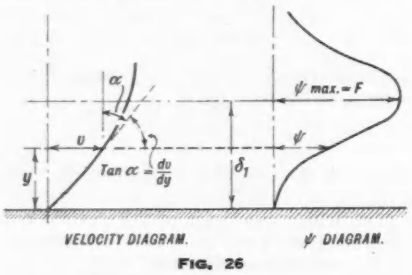


FIG. 26

one type of flow to another occurs at the level which corresponds to the critical value of ψ. We will describe this latter value as F and the corresponding thickness of the laminar layer as δ_1. On the other hand, since in its lower part the laminar flow parabola is almost straight, it may be assumed, with sufficient approximation, that in this reach $\frac{dv}{dy}$ is constant, the shear τ being consequently equal to the boundary shear τ_o.

[62] From Hunter Rouse, *loc. cit.*

The "scala" will then consist of the following elements (see Fig. 27):—

(*a*) A straight part from zero point to the level at which ψ attains its maximum value F.

(*b*) A logarithmic curve, for the upper part of the diagram, with a transition section in between.

It is further assumed that the ordinate y_1 of the theoretical point at which the logarithmic curve intersects the vertical zero

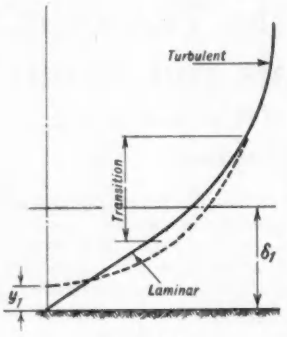


FIG. 27

axis is a certain fraction of the thickness of the laminar sub-layer δ_1, so that $y_1=\frac{\delta_1}{N}$.

Expressing symbolically these various assumptions, there is obtained for the laminar "scala" in the sub-layer:—

$$\frac{dv}{dy}=\text{const.}=\frac{\tau_o}{\mu}.$$

For the critical value of $\psi=F$ and the corresponding ordinate δ_1:—

$$\psi=\frac{y^3\frac{dv}{dy}}{\nu}=\frac{\delta_1^3\frac{\tau_o}{\mu}}{\nu}=\frac{\delta_1^3\tau_o}{\nu^3\rho}=F$$

from which

$$\delta_1=\frac{\nu\sqrt{F}}{\sqrt{\tau_o/\rho}}=F_1y_1 \text{ and } y_1=\frac{\sqrt{F}}{F_1}\frac{\nu}{\sqrt{\tau_o/\rho}}.$$

Substituting this into the equation for the logarithmic curve

$$v=2\cdot5\sqrt{\frac{\tau_o}{\rho}}\log_e y+A$$

we obtain:

$$\frac{v}{\sqrt{\tau_o/\rho}}=2\cdot5\log_e\frac{y}{y_1}=2\cdot5\log_e\frac{yF_1\sqrt{\tau_o/\rho}}{\sqrt{F}\nu}.$$

Experiments by Nicuradze, one of Prandtl's

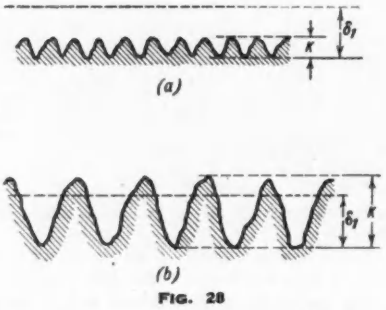


FIG. 28

talented disciples, give the values F and F_1 as 135 and 107.

With these figures the final form of the logarithmic curve is:—

$$\frac{v}{\sqrt{\tau_o/\rho}}=2\cdot5\log_e\frac{\sqrt{\tau_o/\rho}y}{\nu}+5\cdot5$$

$$=5\cdot75\log_{10}\frac{\sqrt{\tau_o/\rho}y}{\nu}+5\cdot5.$$

The thickness of the laminar film δ_1 supplies a very diagrammatic explanation of the modern concepts of "smooth" and "rough" boundary surfaces. Suppose, in the first instance, that the characteristic size of the roughness height, K, is less than δ_1, as shown in Fig. 28*a*.

Under such conditions a laminar film may develop and we will then have the characteristic conditions of a "smooth boundary." On the other hand, it is obvious that if $K>\delta_1$, as in Fig. 28*b*, the laminar sub-layer is impossible and we must therefore apply in this case the equations of rough boundary surfaces. In the first case the discharge is independent of the trough, while in the second it is a function of K.

This, consequently, is the explanation of the age-old controversy about the hydraulic effect of the physical nature of the channel. The thickness of the laminar film decreases as the Reynolds number grows, and for conditions occurring in practice, in canals and rivers, it will always be less than K. Which explains and substantiates the variable roughness factor in the usual discharge formula.

It is therefore of interest to compare the rough boundary equations of the Prandtl-Karman method with the classical discharge formulæ. The boundary shear τ_o will serve as basis for comparison. In fact this shear must be equal to the force of gravity (which is equal to the component of the weight of the water contained between two normal sections, namely, $\nu aLi=\nu aL\frac{y}{L}=\nu ay$) divided by the area of the contact between the water and the boundary (that is, the perimeter of the section, p, multiplied by the distance L between the sections). We will thus have:

$$\tau_o=\frac{\nu ay}{Lp}.$$

In this equation a/p is the hydraulic radius m. Hence

$$\tau_o=\frac{ym\nu}{L},$$

which gives:

$$y=\frac{\tau_oL}{m\nu} \quad \ldots\ldots (a)$$

On the other hand, we have developed the formula

$$y=f\frac{L}{D}\frac{v^2}{2g},$$

where f was the d'Arcy-Weisbach coefficient and D the diameter of the pipe, which we may now replace by $4m$.

Consequently,

$$y=f\frac{L}{4m}\frac{v^2}{2g} \quad \ldots\ldots (b)$$

Combining (*a*) and (*b*) we obtain:

$$\frac{\tau_oL}{m\nu}=f\frac{L}{4m}\frac{v^2}{2g}.$$

Since $\nu/g=\rho$, this gives:

$$\frac{\tau_o}{\rho}=\frac{f}{8}v^2.$$

Substituting this fundamental equation into the Prandtl-Karman formula for the mean velocity in rough channels, namely:

$$\frac{v}{\sqrt{\tau_o/\rho}}=5\cdot75\log_{10}\frac{H}{K}+6,$$

and recollecting that for a wide channel $H=m$, we obtain:

$$\frac{1}{\sqrt{f}}=2\log_{10}\frac{m}{K}+2\cdot11.$$

It is relevant to the present discussion that for a circular pipe the equation would have been

$$\frac{1}{\sqrt{f}}=2\log_{10}\frac{r}{K}+1\cdot67,$$

which, since $r=2m$, can be rewritten:

$$\frac{1}{\sqrt{f}}=2\log_{10}\frac{m}{K}+2\cdot27.$$

Thus, the general form of the Prandtl-Karman equation for the friction coefficient f is:

$$\frac{1}{\sqrt{f}}=2\log_{10}\frac{m}{K}+A,$$

where A is a certain constant and m the hydraulic radius.

B. A. Bakhmeteff and N. V. Feodoroff produced (see "Transactions" of the American Society of Civil Engineers, Vol. 108, 1943, page 496, in "Discussion on Open Channel Flow") a comprehensive diagram (see Fig. 29), which opposes the Prandtl-Karman equation against the most important and frequently used empirical discharge formulæ of practical hydraulics, namely:

The Ganguillet-Kutter equation.

The Manning's formula.

The Bazin's formula.

Starting with the Ganguillet and Kutter formula, it will be remembered that the value $m=3\cdot28$ft represents critical conditions, as regards the effect of the slope i upon the coefficient C.

At this particular point C is independent from i (namely, it is equal to $1\cdot81/n$ in foot units), and this will, therefore, be a focal point for different curves with various values of i. In the diagram two curves are plotted for $i=0\cdot01$ and $0\cdot0001$ respectively, the rugosity factor n being in both cases the same, $n=0\cdot013$.

The Manning formula curve (for the same value of n) will automatically intersect the same focal point.

As regards the Bazin curve, we select the friction factor ν intentionally in such a way that it should meet the other three curves in the same focus—that is to say, we choose $\nu=87n-1$.

There remains the Prandtl-Karman formula. Here, we proceed as follows:—Since

$$C=\sqrt{\frac{8g}{f}}$$

we may write

$$C=\sqrt{8g}\left(2\log\frac{m}{K}+A\right)$$

$$=2\sqrt{8g}\log_{10}m+A_1.$$

In foot units

$$C=32\cdot1\log_{10}m+A_1.$$

For this curve to be co-focal with the other equations, we must have

$$C=32\cdot1\log_{10}3\cdot28+A_1=\frac{1\cdot81}{n}.$$

From which

$$A_1=\frac{1\cdot81}{n}-16\cdot5\text{ (in foot units).}$$

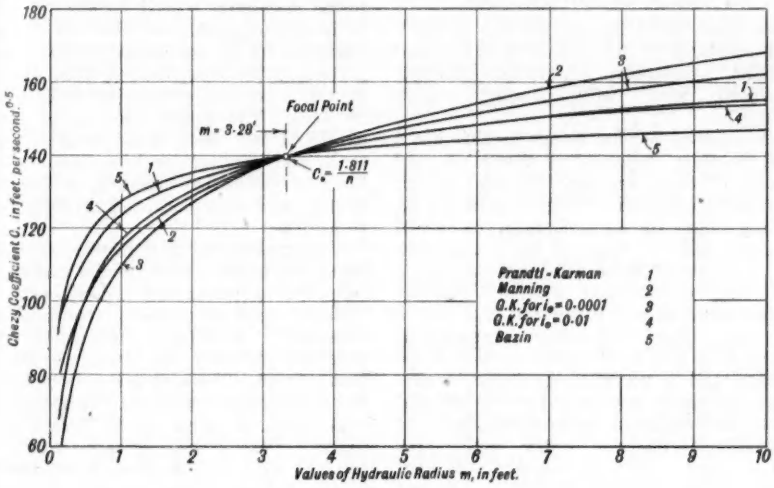

Chezy Coefficient C, in feet per second
Values of Hydraulic Radius m, in feet.
Focal Point
m = 3·28'
C = 1·811/n
Prandtl-Karman 1
Manning 2
G.K. for i = 0·0001 3
G.K. for i = 0·01 4
Bazin 5

FIG. 29

By these means, all the four formulæ are represented on the same basis, and are therefore capable of being compared.

The conclusion that might be drawn from Fig. 29 is that the new "semi-empirical" solution is not inconsistent with the purely "empirical" equations, which, being "*consacrées par l'usage*," may be taken as a sound basis of comparison. In fact, the difference between the five curves appearing in the diagram lies chiefly in the relative steepnesses of their slopes.

Generally speaking, in comparing the relative merits of various alternative empirical equations intended to frame a certain set of records representative of a natural law which we want to trace, it is not only the accuracy of the fit which matters, but also and essentially the number and the constancy of the numerical coefficients included in these equations; for with an infinite number of constants every set of observations may be represented with ideal precision by any arbitrarily selected empirical equation.

Empirical equations with one coefficient only come naturally into the first line, but here again the value of the formula depends on the range of variation of that "constant" and on the effect of such variations on the result; for instance, one of the main objections against Ganguillet-Kutter's formula centred on the excessive variations of n. It is, therefore, materially important that the new theory—whether it be classified as an empirical or rational method—tends towards constant coefficients, which is really the important point of the whole discussion, both for the practical designer and for the academically minded research engineer. And therefore, although so far we still continue using in practice the classical empirical formulæ, there is, nevertheless, sufficient reason for anticipating new developments in the near future, tending towards the introduction of new semi-empirical methods in the routine of practical design.

British Industries Fair

No. III—(*Continued from page 571, May 4th*)

WE continue below the description of some of the exhibits at the Castle Bromwich section of the British Industries Fair. The Fair opened on April 30th and closes to-day.

Road Machines (Drayton), Ltd.

Exhibited for the first time amongst the products of Road Machines (Drayton), Ltd., West Drayton, Middx., is a mobile weigh-batcher. As illustrated, the plant is mounted on a double-axle trailing chassis and it can be hauled at a maximum speed of 20 m.p.h. The chassis can be removed at the site after the plant has been raised and supported on its four screw jacks. This operation, apart from the fitting up of the flare plates, which are hinged or detachable, completes the site erection procedure.

The storage hopper is designed to hold 5 cubic yards of sand and 7 cubic yards of aggregate in separate compartments, and discharge to the weighbatcher is through lever-operated gates of radial design at the base. The weighbatcher unit, which swings about one of the hopper stanchions, comprises a single bucket mounted on a four-point suspension system. Bottom radial discharge gates are fitted in the bucket, which has a capacity of 14 cubic feet, and its scale dial indicates in 5 lb increments up to 1400 lb.

The chassis is of welded construction, but sectioned in small units for shipment.

The most recent design of this plant is to be mounted on a single-axle trailing chassis with two 35in diameter pneumatic-tyred wheels and fitted with internal expanding brakes. The net weight of the plant is 2 tons 3 cwt, and when working it has a height of 12ft 10in, a width of 7ft 6in and a length of 8ft 9in.

Another mobile unit exhibited by this company is a monorail transporter, devised to carry concrete from the mixer to the spreaders. This unit consists of a self-propelled tipping wagon, with or without trailers, running on a single steel rail. The rail can be mounted on the ground or it can

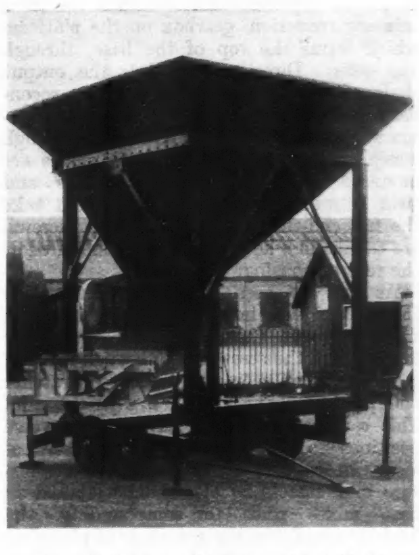


FIG. 19—MOBILE WEIGHBATCHER—ROAD MACHINES

be mounted to utilise scaffolding of the permanent structure.

Included on the stand also is a small dumper with nominal capacities of ½ and ¾ cubic yards. Drive from its engine is taken through three forward gears and one reverse, and it has a top speed of 10 m.p.h. Discharge is by gravity or by hand control.

R. H. Windsor, Ltd.

A new multi-screw extruder with an average output of 100 lb per hour is a recent addition to plastics moulding machines made by R. H. Windsor, Ltd., of 16, Finsbury Square, London, E.C.2. This 100 lb machine, which is exhibited, is one of a group of three similar models, the other two being designed for average

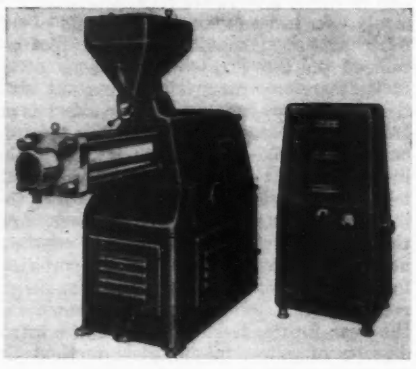


Fig. 20—Twin Screw Extruder—Windsor

outputs of 65 lb and 200 lb. These machines not only extrude but also compound, colour and pelletise vinyl, cellulosic, and polystyrene materials.

In the extruder two screws, which mesh and rotate in the same direction, are designed to improve mastication of the thermoplastic material, and the wiping action of one screw against the other checks any tendency for the material to flow back.

A 10 h.p. variable speed constant torque motor in the rigid cast iron base drives a primary reduction gearbox on the platform which forms the top of the base, through vee belts. Directly coupled to the output shaft of the reduction gearbox is a secondary drive unit, which drives the twin-screw shafts of the extruder through straight spur gears. The screw shafts are mounted on needle roller bearings and twin nitralloy thrust bearings, which take the full end-thrust of the extruding screws, are carried in a heavy steel block mounted at the rear of housing.

As can be seen from the illustration (Fig. 20), the hopper feed is mounted directly above the screw unit, and it is driven from the screw shaft through a fabric gear-wheel and a crank motion to a ratchet and pawl mechanism with a wipe-out cam. This cam can be set in any one of twelve positions to give twelve different rates of feed. In order to avoid the effects of moisture and attack by the chemicals used in base mixes prior to compounding, the feed boot and housing are made of phosphor bronze.

The extruder barrel, of hardened and ground rust-resisting steel, is heated by a 5kW blanket heater. The screws, which are made of hardened and ground alloy steel, have three different diameters and pitches intermeshing with one another. The diameters of the screws are 4·1in, 3·85in and 3·6in, respectively, for the first, second and final stages, and their speeds are infinitely variable between 6 r.p.m. and 17 r.p.m. The adaptor plate in front of the barrel is carried on four heavy tie bars and the adaptor nut which is screwed in it is heated by a 0·75kW heater.

A. Reyrolle and Co., Ltd.

The main Reyrolle exhibits are a 66kV open small-oil-volume circuit breaker and a 33kV metal-clad horizontal-draw-out switchgear panel with complete phase separation.

The small-oil-volume circuit breaker has a rated breaking capacity of 2500MVA and consists of three separate identical single-phase units operated through a self-aligning rotating shaft by a mechanism contained in a steel cubicle. Each of the single-phase units consists of three portions, namely, a supporting compartment, a circuit-breaking compartment, and a metal top-cap with a gas vent. The supporting compartment forms a base and includes an oil-filled metal chamber and a porcelain insulator, within which the operating links for the moving contact are contained. The circuit-breaking compartment includes upper and lower fixed contacts; the moving-contact stem slides through the lower fixed contacts and all the contacts are contained in a cylindrical Bakelised-paper tank surrounded in turn by

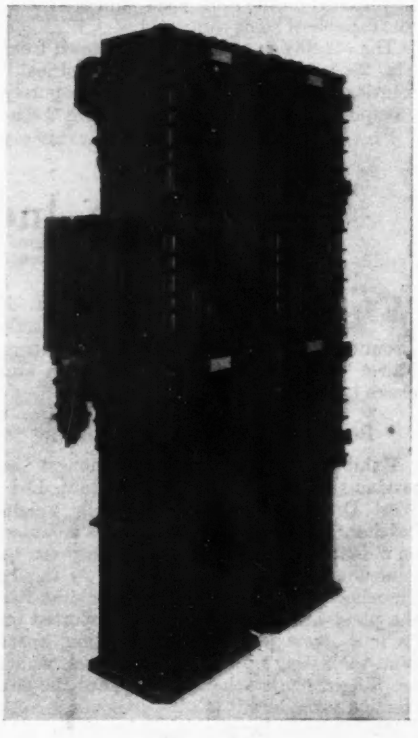


Fig. 21—Air Insulated Flameproof Motor Starting Switchboard—Reyrolle

a porcelain insulator. The oil in the bakelised-paper tank, used as the arc-extinguishing medium, is entirely separate from the insulating oil, which fills the supporting compartment below and the annular space between the tank wall and the upper porcelain shroud. The metal top-cap, from which the upper fixed contact with its turbulator arc-control device is suspended, is fitted with a silica-gel breather and oil-level indicators. In the exhibit one of the single-phase units has been cut away in section to show the construction; operation is by a precharged motor-wound spring mounted in the mechanism cubicle. The circuit breaker is spring opened, and the mechanism is so arranged that the closing spring can be recharged with the circuit breaker closed, thus providing for single-shot reclosure.

The other main exhibit, the metal-clad circuit breaker, has a rated breaking capacity of up to 1500MVA, and it is supported on frame standards spaced at 4ft 9in centres. It is of the established Reyrolle horizontal draw-out design, and one of its characteristics is its total phase separation, from the busbar chamber to the circuit cable boxes. To illustrate this point the circuit breaker exhibited has been fitted with a perspex tank, and perspex windows have also been fitted in the busbar chamber, in the current transformer chamber, and in the voltage transformer.

The application of flameproof switchgear to control plant in oil refineries and chemical factories, in which fire hazards exist, is a matter receiving increasing attention, and a four-panel flameproof contactor board designed specially for such situations is being shown. The unit principle of assembly has been adopted (Fig. 21) with 80A, 550V contactors mounted above and below a common busbar chamber, each pair of contactors with its busbar chamber being mounted on a common pedestal. The busbar chamber is a separate flameproof compartment, which also houses two three-pole isolators controlling their respective contactor circuits. Each contactor chamber contains a three-pole electrically-held-in contactor (which may be operated locally from push buttons on the cover or remotely from control stations or float switches), as well as over-current and earth-fault protective devices and three Reyrolle class "GP" cartridge fuses to provide short-circuit protection. The isolators are suitably interlocked with the contactor chamber covers, which are hinged. Circuit and pilot cable boxes are provided on the backs of the units, and incoming busbar cable boxes can also be fitted.

Holman Brothers, Ltd.

The pollution of the surrounding atmosphere by dust has long been a problem in rock drilling, particularly in mines and

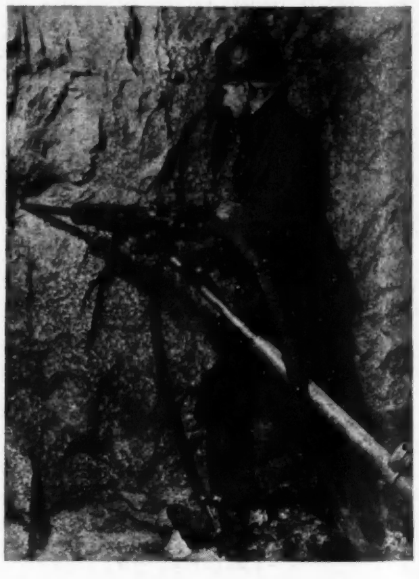


Fig. 22—Dustless Dry Rockdrill in Operation—Holman

confined spaces. This trouble has to some extent been overcome by projecting a heavy spray of water on the surface being drilled,

but the heavy sludge formed tends to collect below the hole, and, once it has dried out on the floor, the dust is lifted in clouds upon a shot being fired in the locality.

On the stand of Holman Brothers, Ltd., of Camborne, Cornwall, there is to be seen in operation the latest equipment developed by the firm to overcome this dust problem. It consists of a drill of new design, which incorporates an ejector by which the dust formed at the drill head is drawn out and ejected some distance away from the working point. The new drill, known as the "Dryductor," is illustrated in operation in Fig. 22.

In the new equipment a passage is formed right through the body of the drill and the centre of the tool. As a hole is drilled into the rock the dust is drawn through the passage in the tool and in the drill, and ejected rearwards through a length of hose pipe connected to the back of the drill. Various schemes have been devised for disposing of the dust either in a portable separator chamber near the drilling point, or through a pipe-line to a central disposal station serving a number of drills.

In addition to providing an effective means of preventing the free flow of dust into the atmosphere when drilling the new unit provides a continuous supply of finely crushed ore for sampling purposes when drilling exploratory holes. Such holes can be driven to depths of up to about 18ft.

Together with this new drill the firm is showing a representative selection of its compressors and different types of pneumatic tools.

Metallisation, Ltd.

Of particular interest in the outdoor exhibits at Castle Bromwich is a fully automatic metal-spraying machine, which has been developed by Metallisation, Ltd., of Dudley, Worcestershire.

In this machine there is combined a Tilghman grit-blasting unit and a metal-spraying unit. A specially designed conveyor unit first carries the tubes to be treated through the grit blast at a predetermined speed whilst they are being rotated. The tubes pass on to the metal-spraying machine, illustrated in Fig. 23, where ten heads are arranged to spray an aluminium coating 0·004in thick on to the tube surface under controlled conditions within three seconds of being cleaned.

Tubing from ¾in to 2¾in outside diameter can be handled in the machine at a rate of 20ft per minute. Only two operators are required to work the machine which can coat up to 9600ft of tube per day. The spraying heads are designed on similar lines to the firm's metal-spraying pistols and are carefully arranged so that they coat the tubes with an even thickness of aluminium.

In the spraying heads compressed air at 50 lb per square inch is used to atomise the metal, which is melted at the nozzle tips by a mixture of propane and oxygen piped from manifolds. The heads are driven by electric motors through reduction gearboxes of the variable-speed type, which can be adjusted according to spraying requirements.

Doulton and Co., Ltd.

Porcelain insulators for all kinds of electrical installations are displayed on the stand of Doulton and Co., Ltd., Albert Embankment, London, S.E.1. The range of insulators made by this company is steadily increasing, and those for switchgear and transformers are now available for up to and including 66kV working voltage, whilst overhead pin-type porcelain insulators are made for working voltages up to 22kV.

Also to be seen on the stand at Birmingham is a very wide range of the firm's porous ceramic media for filtering, aerating and electrolytic processes. These media, made from a variety of acid-resisting ceramic materials, are being used for such processes as the filtration of either gases or liquids; aeration, including the intimate mixing of one fluid with another or of a fluid with a powdered solid; the segregation of certain of the constituents in electrolytic processes; crystal drying, &c.

Among the units displayed is a stainless steel pressure filter equipment, designed primarily for laboratory or pilot-plant work and fitted with an 8in by 1in candle which is available in a range of porosities from less than half a micron to approximately 750 microns, measured maximum pore size. The ease with which the filter element can be removed, cleaned and replaced makes this unit useful where a variety of filtration problems have to be handled. It is particularly suitable for use as an air-line filter for the protection of moving parts in sensitive apparatus.

A new type of pressure filter which is shown is designed to provide a large-capacity unit, suitable for running at high pressures. With it the time required for maintenance is reduced to a minimum, and it is easily cleaned by back-flushing, there being adequate space for thick cake build-up and heavy sludge accumulation.

This unit comprises fifty-four porous candles, 10in by 2in, in banks of three on eighteen perforated tube fittings. The three elements on a fitting can be brushed clean without being removed from the perforated tube, and they can be replaced immediately in position.

External piping and valves provide for back-flushing, and the bottom of the unit slopes towards a quickly removable sludge door, which is large enough to allow an arm to reach inside the casing.

A pressure gauge fitted on to the outlet chamber on the top front of the unit indicates when cleansing is advisable and gives immediate warning of any failure.

The number of 10in elements in the unit can be adjusted to multiples of eighteen by increasing or decreasing the length of the perforated tube fittings and the length of the steel tube between top and bottom castings.

Newton Victor, Ltd.

The main exhibit shown by Newton Victor, Ltd., 15, Cavendish Place, London, W.1, is a complete mobile industrial X-ray unit suitable for the examination of castings and welded joints, &c., up to a thickness corresponding to 3in of steel. As illustrated in Fig. 24, the "Raymax 250" unit is a self-contained plant, mounted on pneumatic-tyred wheels, and arranged so that the X-ray apparatus can, when required, be taken to the job and used in any part of a works or yard where an electric power supply is available. The complete "Raymax 250" unit is of rugged construction, designed for service with "heavy" industry.

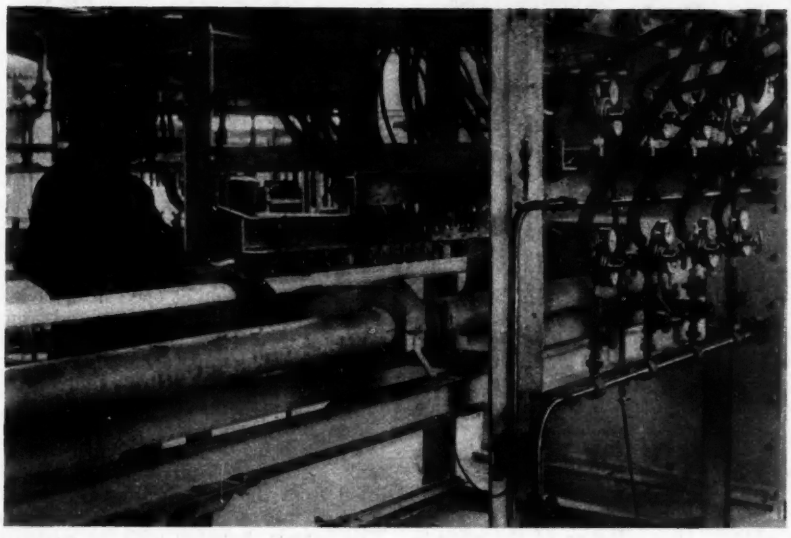


Fig. 23—Tube Spraying Machine—Metallisation

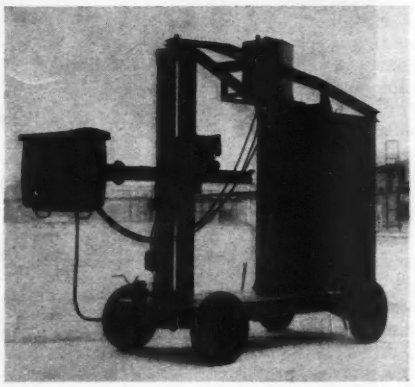


Fig. 24—"Raymax 250" Industrial X-ray Unit—Newton Victor

The high-voltage transformer and X-ray tube are oil immersed in a single tank within the tube head—a method of construction which obviates the use of high-voltage cables and the deleterious effects of atmospheric humidity. Cooling is provided by oil flow from a heat exchanger which is fitted on the chassis and is independent of water supplies. With this system of cooling the tube is designed to operate continuously at 250kVp and 10mA.

The tube-head is mounted on a jib crane with a motor-driven vertical travel of 6ft and a manually operated horizontal movement of 4ft. In addition, the tube-head rotates about both its horizontal axes and about the vertical stanchion of the crane. This unusual freedom of movement for orientating the X-ray beam in all directions

is convenient when examining large specimens and intricate castings, and is particularly useful where a large range of products has to be inspected or when the works cranes are overloaded.

The control panel is mounted inside a lead-lined cab at the rear of the chassis, giving full protection to the operator from radiation during X-ray exposures. The panel is self-illuminated and the controls are so arranged that any desired exposure time can quickly be set—an electric timer terminating the exposure automatically at the end of the predetermined period.

Gas Council

To supplement the many examples of gas-fired appliances and equipment the Gas Council has arranged on its stand models showing the main features of some of the large equipment recently installed in this country using gas as the heating medium.

Forming the centre piece of the stand is a full-size bogie furnace for annealing and stress relieving, similar to a unit being installed by the Dowson and Mason Gas Plant Company, Ltd., of Manchester, at the works of the Motherwell Bridge and Engineering Company, Ltd. This new furnace is designed to take loads of up to 100 tons and if required. Furnaces of this type are suitable for the bright annealing of both ferrous and non-ferrous metals in the form of pressings, strips, wire, sheet and tubes at temperatures up to 1000 deg. Cent. A conditioned atmosphere, suitable to the class of metal being treated, can be maintained through all sections of the furnace.

A special display is arranged to show the range of gas burners available for various industrial purposes. The equipment shown ranges from natural draught burners, both pre- and post-aerated, to medium and high-pressure burners. Natural draught burners of the post-aerated type are used for the conversion or firing of central heating boilers, bakers' ovens, vat heating and other comparatively low-temperature applications. The pre-aerated natural draught burners are usually used where direct contact with the flame is necessary, though they are also suitable for certain other furnace applications.

The medium-pressure burners shown give a fairly long flame, with a higher radiation factor than the higher pressure burners, and are suitable for several kinds of furnace and for processes where a quicker rate of heat release is required than can be obtained with the natural draught burners. The high-pressure burners are of the type specially suited to heat-treatment and metal melting furnaces, and to certain furnaceless heating processes, as with the concentrated combustion burners. Two of the high-pressure burners shown are for high-pressure gas, and there is a burner developed to provide a high radiant emitter for special drying products.

The exhibit is arranged so that each separate burner lights in turn, and has a mirror fitted, which enables the observer to see the combustion conditions within the burner tunnels.

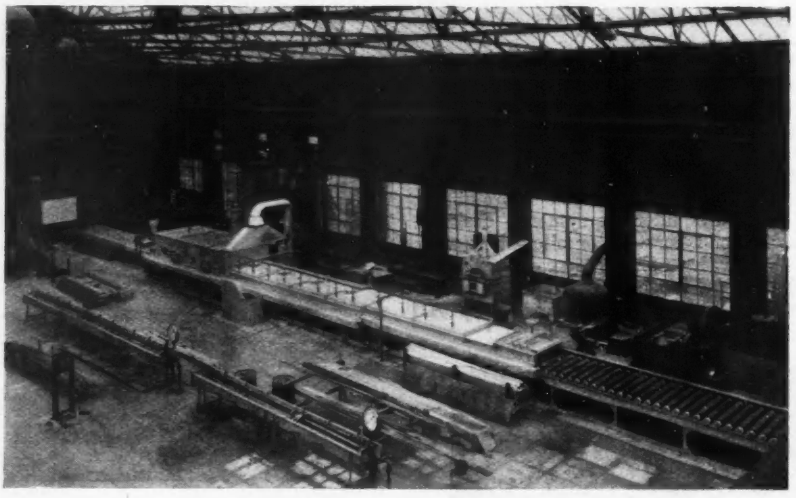


Fig. 25—Continuous Furnace—Gas Council

its maximum gas consumption will be 26,000 cubic feet an hour. It is believed to be the largest town's-gas-fired furnace ever built in this country.

Also shown on the stand is a model of the roller hearth conveyor furnace, illustrated in Fig. 25, which was built by the Incandescent Heat Company, Ltd., of Smethwick, for the Yorkshire Copper Company's Glasgow works, where it is used for continuous heating processes. The furnace is heated by the combustion of gas inside heat-resisting tubes. These tubes generate and radiate heat, the products of combustion being kept entirely out of contact with the load in the furnace. The tubes are fired from the charging end of the furnace and are provided with special controls and air-gas ratio proportioning. Each tube has an individual calibrating valve, so that, if necessary, more heat may be delivered towards the base of the shell, where the wall thickness may be greater.

The conveyor is designed for continuous rotation of the supporting bases to ensure even heating throughout, and the temperature for annealing can be controlled to within plus or minus 5 deg. Cent. An air blast cooling section can be fitted to the furnace,

Thompson Brothers (Bilston), Ltd.

In addition to a selection of the plant it makes for the chemical, oil, food and other industries, Thompson Brothers (Bilston), Ltd., is exhibiting for the first time a liquid spelter pump such as that illustrated in Fig. 26. This type of pump can be used for transferring the spelter from one galvanising bath to another or emptying the contents of a bath into metal containers. It has a rated capacity of 75 tons an hour and it can, if required, be fitted with a reducing device to control the flow down to 10 tons an hour.

Molten metals or other hot fluids up to 460 deg. Cent. can be handled by the pump.

The unit consists of a centrifugal pump with an impeller of special design housed in a casing at the lower end of a long tubular member. The casing is fitted with a perforated semi-spherical rose intake and long slots in the tubular member lead down to the pump. From a driving motor at the top of the tubular member a driving spindle extends down to the pump, and a sealing gland prevents hot gases, &c., passing up to the motor.

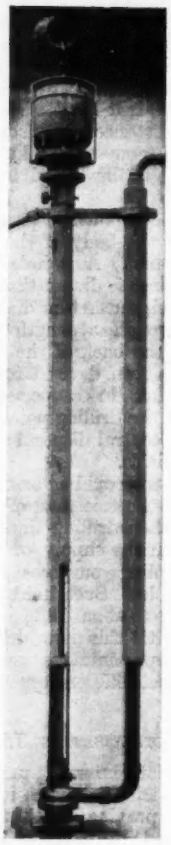


Fig. 26—Spelter Pump—Thompson

W. Canning and Co., Ltd.

In a semi-automatic, totally immersed barreling unit for nickel shown by W. Canning and Co., Ltd., of Birmingham, the work is loaded into moulded rubber barrels on a loading station at one end of the plant. A lifting block on an overhead runway system is used to transfer the barrels through the various stages till they reach an unloading station at the far end of the unit. At each process tank the barrel is rotated through a clutch unit which is disengaged whilst a barrel is being lowered or lifted from the tank. At the unloading station a barrel is lifted from the final swill and its contents emptied into a hopper immersed in a tank. This hopper, together with its contents, is removed by hoist and conveyor to a separate drying unit.

The unit is the firm's latest development in totally submerged plating barrels and is specially designed for handling large loads. It may be used for the deposition of most common metals other than chromium. The totally immersed barrels will deal with as much as 12 gallons of articles or a load not exceeding 2 cwt.

An external loading bay on the unit provides for easy manipulation, both in loading

and unloading, and eliminates any danger of dropping articles into the tank, and an electrical raising and lowering mechanism facilitates handling of substantial loads.

Transfer of the barrel to the swill tank takes about fifteen seconds, and the speed of transfer minimises risk of staining of the plated articles.

The perforated barrel offers little restriction to the flow of electrical current and permitting free circulation of the solution. The form of construction permits the use of a high current and a consequent rapid rate of deposition.

HAWKER SANDERS, LTD.

A useful range of flexible shaft equipment for all classes of work is now made by Hawker Sanders, Ltd., of Richmond Road, Kingston-upon-Thames, and an interesting feature in these tools is a rapid-release interchangeable tool head which has been developed.

The arrangement of this tool head and its operation is clearly shown in the diagram we reproduce in Fig. 27. The flexible driving shaft is coupled to the shaft of the rearmost driving dog clutch member *A*, the flange of which is carried against a ball thrust bearing. This driving member is contained within a sleeve having a bayonet socket head. It will be seen that when the second tool head member *B* is inserted in the sleeve and its bayonet pins registered in the grooves the spring-loaded driven member *C* of the dog clutch is engaged with the driving member. This driven member is extended to form the collet shaft of the head. When a tool has been inserted in the collet the nut *D* is tightened to grip it rigidly on the shaft. When the two parts of the head are engaged a locking collar is screwed over the bayonet fitting.

The firm makes a wide range of units for use with this type of tool head, including grinding and buffing wheels, sanders, shearing and nibbling heads, &c. With a range of these units adapted for the rapid release interchangeable drive a single power unit is made quickly and easily available for many classes of work.

FIG. 27—INTERCHANGEABLE TOOL HEAD—HAWKER SANDERS

(To be continued)

Engineers and Architects

(Contributed)

IN studying the evolution of engineering science, the student cannot fail to be impressed by the extent to which sheer necessity has acted as the impelling force. The very cradle of engineering is found in certain Mediterranean territory, which, being unfruitful, imposed upon its inhabitants the need to foster trade so that they might, by exchange, secure those things of which they stood in need and of which other people had a surplus. Thus, for example, began deep sea navigation, the solution of the problems of which must have involved great trials and sacrifices. What difficulties may have beset Ulysses in constructing his own boat we do not know, but the fact that he built it himself confirms the scarcity in his time of competent workmen. While the Odyssey tells us quite a lot about the cargoes of the ships of Sidon—then the most important of all exporting centres—we cannot expect Homer to provide details of ship design and equipment, though the extent of Phœnician shipbuilding and the length of the voyages made by their ships as long ago as the thirteenth century B.C., are things to marvel at, just as we marvel to find in Egyptian papyrus of the sixteenth century B.C. a calculation of the surface of a hemisphere from its diameter. This gives the constant π as 3·16, a very fair approximation. It is to be remembered that there is nothing slipshod about the surviving work of these early technicians and architects. It would, indeed, be stimulating to many of our modern practitioners if they examined that marble slab on which, about 409 B.C., Philocles, the architect, Etearchos, secretary to the Commissioners, and others unnamed, inscribed their report on the condition of the Erechtheum at Athens and presented to the Commissioners a detailed specification of the recommended repairs. Certainly the quality of the ancient Mediterranean workmanship was of a high order. We read that when, in the fourth century B.C., Alexander the Great set siege to Tyre. he found it an extremely hard nut to crack and it was only with tremendous exertions and the use of every device known to the warfare of the day that he succeeded in capturing the city and reducing it to "a place for the spreading of nets in the midst of the sea." We have a considerable amount of information regarding the devices used by the military engineers of antiquity, who were not only highly ingenious but possessed a very good notion of the strength of the materials with which they worked. In the extant records of these early craftsmen we find much to wonder at and discover good evidence of the extensive use of devices for aiding labour and of the emphasis placed on providing a large margin of strength. Herodotus, who examined the great buildings in Egypt, has put on record quite a lot of detailed information mentioning, *inter alia*, the extensive use of machines to transfer the heavy blocks from the inclined planes up which they were brought. It is indeed to their architecture and their building methods that we must look for the most arresting evidence of the engineering skill of the ancients.

Architects and engineers stem from the same root. Indeed, it has been said that the father of architecture was Marcus Vitruvius Pollio (commonly called Vitruvius), who worked for Julius Cæsar as an inspector of military engines and whose "Architectura" is dedicated to Augustus. While we know of only one building set up by Vitruvius himself, he has bequeathed a great amount of information compiled with such fullness of detail as to show him to have been a man thoroughly acquainted with his subject. He shows marked sagacity, moreover, in that place where he affirms that "architecture has for its parents practice and theory; the first is the result of the frequent and continued contemplation of the mode of executing any given work, or the operation of the hands for the conversion of the material in the readiest way: theory is the reasoning produced by that contemplation, demonstrating and explaining that the material wrought answers the end proposed, and on him alone who is familiar with both branches of the art can the title of architect be justly bestowed." Vitruvius comes rather late among the engineers of antiquity, since it is recorded of Uzziah, King of Judah (who reigned about 800 years B.C.) that he made engines "invented by cunning men, to be on the towers and upon the bulwarks, to shoot arrows and great stones withal." In the time of our Norman kings we find records of similar cunning men, among whom was Alnoth, employed by Henry II as master of the works at the Tower of London, Windsor and elsewhere. Alnoth was called the king's "Ingeniator" and the same title was given to a master of the works employed by Richard I and to two building masters working at Durham. It is not to be doubted that the early building masters and architects were the experts in "war engines."

It is interesting to compare the procedures followed by architects and engineers in the design and construction of those large, spherical roofs which we call cupolas or more popularly, "domes." Among the oldest of such structures—and it dates from about A.D. 532—is the dome of the basilica of St. Sophia, in Istanbul. This work is attributed to two architects who worked for Justinian, their names coming down to us as Anthemius and Isidorus. The diameter of the dome of St. Sophia is 108ft and in order to restrict the weight of the spherical vault, the architects used pumice stone and Rhodian bricks. About five centuries later the Italian engineer who designed the dome of the Baptistery at Pisa simplified the problem by using a conical wall, which supported the upper part of the external dome, projecting through it to form the lantern. When, after a further period of about five centuries, Sir Christopher Wren planned the dome of St. Paul's, he followed the design used for the Baptistery at Pisa, the great weight of the stone lantern at St. Paul's being carried on a conical brick wall, the external dome being an ornamental spherical roof. Wren is perhaps the outstanding instance, in modern times, of the engineer-architect, though he was doubtless considerably indebted to his collaboration with Robert Hooke, one of the most brilliant engineers and physicists of the seventeenth century. As with Wren, so with the great Italian architects, such as Brunelleschi, Bramante, Michelangelo, Vignola and others. They were engineers as well as architects and their works remain, to this day, among the treasures of civilisation.

CO-ORDINATION OF MINING SURVEYING POLICY.—The Royal Institution of Chartered Surveyors and the Institute of Mining Surveyors announce that they have appointed a joint committee to advise the councils of the two societies upon questions affecting mining surveying policy, with the object of securing a concerted approach to the subject. The joint chairmen of the committee are Mr. C. P. Bates, F.R.I.C.S., and Mr. N. E. England, F.R.I.C.S. All communications should be addressed to the joint secretaries at 12, Great George Street, Westminster, London, S.W.1.

British Train Speeds

FOR some little time now comment has been freely offered upon the relative slowness of present-day British train speeds in comparison with those of America and France. It might well seem extraordinary that France, after suffering from five years of enemy occupation and the intense bombing of communications that preceded her liberation, should have been able to restore train services to such an extent as to show, during the summer service of 1950, a daily mileage of 11,800 run at booked speeds of 60 m.p.h. or over, while the British total is no more than 44 miles. At 55 m.p.h. and over the French total was 28,600, against the British 4600. In America the mileage run at high speed is far greater even than the French ; no fewer than 3260 miles daily are booked at 75 m.p.h. or over, while the "over 60" figure is 141,700, made up of 2552 individual runs. The comparison is sufficiently striking to arouse very strong comment, but rather than attempt to compare conditions in the three countries the aim of this particular article, collected from the experience of a considerable number of correspondents, is to examine the British position in some detail.

A study of "Bradshaw" reveals some considerable variations in different parts of the country, and sometimes variations over the same route. The latter cannot be put down to considerations of train loading, as they were often in pre-war days, because some of the lighter trains now have the slower timings. On the Western Region lines, scheduling of the faster trains is arranged to suit maximum engine loadings, though nowadays such loadings are rarely reached, even at week-ends. As a first example, the running times of the present 5.5 p.m. express from Paddington may be compared with those of the pre-war "Bristolian." The latter was a strictly limited train booked at high speed ; the present 5.5 p.m., loads to about 360 tons tare on most days, but is timed so that engines of the "Castle" class can work it with the full rostered load of 455 tons tare, which is sometimes reached on Friday nights. The booked speeds from point to point were, and are, as follows :—

TABLE I

	Pre-war "Bristolian"	Present 5.5 p.m.
Paddington		
	49·7	43·6
Southall		
	70·5	59·4
Slough		
	75·0	58·3
Reading		
	76·1	55·5
Didcot		
	72·7	57·0
Swindon		
	74·2	59·0
Chippenham ...		
	72·6	59·6
Bath		
Load, tons gross behind tender	245	485 (max.)
Average speed over 106·9 miles, London to Bath	70·0	55·6

The foregoing is a logical case of slower timing, due to heavier loading. The present-day equivalent of the "Bristolian" now leaves Paddington at 9.5 a.m. This train is also liable to peak loading, and is timed accordingly, though on other routes such heavy trains were regularly taken on fast pre-war schedules, that such an argument does not apply. Between Grantham and King's Cross, for example, in pre-war years several trains were booked to cover this 105·5-mile stretch at an average speed of 60 m.p.h. The Gresley "Pacific" engines kept that timing with loads up to 550 tons, yet the regular booking nowadays over that same stretch is more than 2 h 124 min, to be exact.

It is when the intermediate bookings of some long through journeys come to be examined that further disparities are revealed. Table II shows the point-to-point speeds of the present "Tees-Tyne Pullman," between Darlington and King's Cross against those of the "Flying Scotsman" on its seven-hour Edinburgh-London non-stop journey in pre-war days, and of the high-speed "Coronation," introduced in 1937.

TABLE II

Train	Tees-Tyne Pullman	Pre-war "Flying Scotsman"	"Coronation"
Load approx. tons ...	335	480	325
Darlington	60·4	62·8	65·0
Northallerton... ...	66·8	66·8	66·8
Thirsk	73·5	66·0	73·5
Alne...	61·2	58·5	61·2
York	55·2	50·2	59·2
Selby	48·0*	56·7	71·1
Doncaster	59·7	61·4	74·5
Retford	63·4	61·7	74·8
Newark	54·8	54·8	73·1
Grantham	54·6	64·7	74·3
Peterborough ...	60·0	55·3	70·0
Huntingdon	63·5	64·8	77·2
Hitchin	60·8	56·8	77·5
Hatfield	40·8*	57·3	66·4
King's Cross			
Average speed for 232·2 miles... ...	56·9 m.p.h. start to stop	59·7 m.p.h. pass to stop	70·8 m.p.h. pass to stop

* Includes "recovery time"

On the above stretch there are regular slacks through York and Peterborough, both rarely passed at more than 15 or 20 m.p.h., and a lesser slack through Selby.

The point immediately to be noticed is that the speed of the "Tees-Tyne Pullman" is practically equal to that of the "Coronation" as far south as York, but that afterwards it approximates with only 335 tons to that of the pre-war 480-ton "Flying Scotsman." Generally speaking, the present-day variations can be traced to the condition of track maintenance, which, as any regular traveller can discern for himself, is much better in some places than in others. The main line of the North-Eastern Region is now in first-rate fettle, and details were published recently of a run with the up "Tees-Tyne Pullman" on which 9 miles consecutively were covered at an average speed of 87·8 m.p.h., including a sustained maximum of 90 m.p.h. on dead-level track. The Western Region has found it possible to raise the speed limit from the general maximum of 75 m.p.h. to 85 m.p.h. on a number of stretches in the West of England, and very fast running is regularly made in Scotland between Forfar and Perth. On some important routes restrictions appear to be no more than local. On the Crewe-Carlisle main line subsidences from colliery workings are giving a good deal of trouble in the Warrington-Wigan-Preston area, though on this route the regular timings of the Anglo-Scottish expresses show a reduced standard of running that is not by any means accounted for wholly by these local restrictions. Table III shows the point-to-point running speeds of the "Royal Scot" of 1938 between Crewe and Carlisle, compared with a heavy train schedule of to-day over the same stretch.

TABLE III

Train	"Royal Scot," 1938–9	Present-day standard
Load behind tender	450 (max.)	550 (approx. max.)
	m.p.h.	m.p.h.
Crewe	60·2	53·5
Warrington	54·0	35·1*
Wigan	54·0	43·7*
Preston...	59·7	54·5
Lancaster	75·6	63·0
Carnforth	54·9	45·2
Oxenholme	49·2	39·3
Tebay	36·7	27·5
Shap Summit ...	62·8	58·3
Penrith...	62·8	48·6
Carlisle		
Average speed for 141 miles	56·8 m.p.h.	46·6 m.p.h.

* Colliery area.

It is true to say that on many of these present day schedules the tractive power of modern locomotives is frequently used to recover time lost by incidental delays, and on a recent journey one of the Stanier "Pacific" engines of the "Duchess" class regained 18 min of lost time between Crewe and Carlisle with a load of 475 tons. An even more remarkable case took place on the down "Queen of Scots Pullman" from King's Cross to Leeds, when 10 min out of a 12 min late start were recovered, although the train suffered nearly 20 min of further delay *en route*. The booked average speed over the 185·8 miles from London to Leeds is 53 m.p.h. so that the net gain of 30 min on schedule brought the net average to 62 m.p.h.

There is, indeed, ample evidence from almost every part of the country that present-day locomotives could maintain far higher average speeds than are at present scheduled if—and it is a very big "if"—optimum standards of maintenance, both of track and locomotives could be kept up, and if—an equally big "if"—the line could be kept clear for the trains to get unchecked runs. Unhappily, there is evidence to show that even the present diluted standards are not everywhere being held. On one particular 90-mile stretch, a fast-running main line normally having no restrictions whatever, there are now three stretches totalling 13 miles, at well separated localities, where speed is restricted to between 50 and 60 m.p.h. due to condition of the track arising from arrears of maintenance. Clearly acceleration of express train services cannot be expected while such conditions exist.

Difficulties of this kind arise from much the same social conditions that cause such disparities in the standards of locomotive maintenance. Where some alternative employment is available, particularly in factories working on a five-day week, acute difficulties arise in the recruiting of labour for railway work—permanent way, shed staff and footplate men alike. As a general rule the highest all-round standards are to be found where the only alternative forms of employment

offer less attractive working conditions. There are, of course, some notable and inspiriting exceptions where the old traditional pride in railway service is being upheld; but such examples can usually be traced to an inspired local leadership. From general experience in recent months difficulties with coal do not appear to be so prevalent as they were a few years ago, and they are largely confined to engines engaged on long through workings where two or more crews in succession are concerned on the same engine.

The extent to which track maintenance on some of the heaviest worked lines had to be allowed to fall into arrears during the war is still not fully appreciated. Not only was periodic inspection and day-to-day fettling-up reduced, but such lines carried an unprecedented amount of traffic. In this respect one can draw a line of sharp distinction between British and French conditions. In the first case the decline in maintenance standards was steady and general, resulting in a vast accumulation of arrears, while in France traffic was not generally heavy at all during the occupation, and rehabilitation took the form of repairing a number of definite breaches, due to bombing, the intervening stretches remaining in good order. Therefore in Britain to-day, the relaying programme is heavier than normal, involving more drastic slacks in running, and yet the available labour, in some localities at any rate, is unable to cope with normal maintenance of alignment and level, with consequent impositions of slight restrictions to 50 or 60 m.p.h.

To the passenger, perhaps the most serious and irritating feature of British passenger services at the present time is that all too often signal checks prevent even the moderate booked speeds of to-day from being maintained. This is an aspect of train running on which the observer can stray on to delicate ground; yet from the very uncertainty as to their cause signal delays can be as demoralising to engine crews as they can be annoying to the passenger. A few causes of signal delays may be set down thus :—

(*a*) Due to engine troubles on other trains ;
(*b*) Late running of other trains ;
(*c*) Faulty regulation of traffic ;
(*d*) Inherent weaknesses in timetable arrangements.

There are many other factors, some not unconnected with the human element, but the four mentioned constitute some of the major troubles.

Engine difficulties can arise from a variety of causes. Although a close watch is kept on all engine workings from the divisional control offices, unbalanced workings may lead to shortages at one or more depots, and sometimes trains have to be sent out worked by unsuitable engines. All too frequently such trains seem to be despatched in a spirit of "hoping for the best." The control system, as initiated on the Midland Railway more than forty years ago provides an admirable means of watching over train workings, and one might imagine that the complex organisation would very soon be able to provide some assistance for an underpowered train. On the Midland, if control information showed that a particular train was losing time an assistant engine was made available as early as possible, and its driver instructed to give every help in recovering lost time. Recent experiences seem to indicate that present-day control organisation, with its elaborate network of telephones, finds it difficult to cope with such emergencies.

A specific case will make this point clearer. One evening last summer, Carlisle was, for some reason, unable to provide anything larger than a Class "5X" 4–6–0 of the "Patriot" class for the first up night express to London, a heavy train of over 500 tons. Clearly time was going to be lost. Worse still, this train, leaving at 12.8 a.m., was followed by others at 12.18, 12.24, and further heavily loaded expresses were scheduled to leave between that time and 1.38 a.m. When the leading train eventually reached London it was nearly an hour late, and the whole subsequent procession of southbound night expresses was queued up, running block and block behind it. One would have thought that control, on being advised of the deficiency in engine power on a train of such critical importance to the whole service, would have taken urgent measures to provide an assistant engine at the earliest possible point. If Carlisle was unable to do so, Carnforth or Preston might have been advised in time. In contrast to this there are occasions when keen and intelligent work assists in the quick restoration of important trains to their normal paths.

A good deal of blame for delays to passenger trains is often placed on the doorstep of the freight service; but freight traffic to-day is not greatly different from that of twenty-five years ago. The Second World War, with its emphasis on the need for keeping freight on the move, did definitely foster a different attitude towards the priority to be given to passenger trains, and severe delays to the latter tend to be overlooked, when once they would most certainly not be. Most significant of all, perhaps, is the way in which the special postal trains are sometimes held up. A few years ago details were published in our contemporary, *The Railway Magazine*, of some runs with the West Coast postal special, on one of which adverse signals caused a loss of 14 min near Carnforth, and on another a local train was allowed to precede the "Postal" from Stonehaven to Aberdeen, and caused a loss of 11 min. At one time such delays would never have been tolerated by the Post Office; but to-day, judging by complaints in the Glasgow district about business difficulties arising from the rather frequent late running of the northbound postal special, it would seem that little is done about it.

To sum up, we have tools for the job. While not a great deal has been done since the war to extend colour light signalling, the control system has been extended and its equipment elsewhere modernised. New locomotives of modern design have been built in considerable numbers since the war. With permanent way the position is not so clear, but with some regions pointing the way general improvement should be possible. What is now needed is effective use of the tools we have.

A Large British Fertiliser Factory

A NEW factory for the manufacture of fertilisers which was recently opened at Immingham by Fisons, Ltd., is the largest plant of its kind in the country and the first to manufacture triple superphosphate. The decision to build this new factory was made some five years ago when the Government appealed to the fertiliser industry to make this country as independent as possible of imported supplies of superphosphate for agriculture. Despite the difficulties which it anticipated would be encountered owing to labour and material shortages, the company decided to embark on a major project and build a plant with an annual production capacity of 70,000 tons of granular triple superphosphate, 50,000 tons of single superphosphate and 75,000 tons of granular compounds.

Triple superphosphate was first used to any extent by farmers in this country during the late war, when supplies were sent here from America. This material has a number of advantages in agriculture as it contains about two and a half times as much soluble phosphoric acid per ton as ordinary superphosphate, and its distribution on the land gives a large measure of economy. The material was imported in powder form, but Fisons decided to produce it in granular form which would, although increasing the amount of plant required in manufacture, speed the rate of production, facilitate storage and ease the work of distribution on the land.

The decision to build the new factory at Immingham was made because of the excellent dock facilities and good rail and road communications available in the area. These dock facilities are of particular importance in the economic running of a fertiliser plant in view of the large amount of raw materials required, most of which can be transported more cheaply in bulk by sea than by any other means. The importance of cheap transport will be appreciated when it is pointed out that the main materials imported annually into the factory include 30,000 tons of sulphur, 130,000 tons of phosphate rock, 30,000 tons of sulphate of ammonia, and 10,000 tons of muriate of potash. Some 25,000 tons of coal is delivered annually to the site by rail. A large percentage of the finished products is also exported by sea.

When the factory was being planned it was decided to mechanise to the greatest possible degree and the effectiveness of this planning is now shown by the fact that this plant, with its large output of fertilisers, can be run with a total personnel of only 350, including office staff and shift workers.

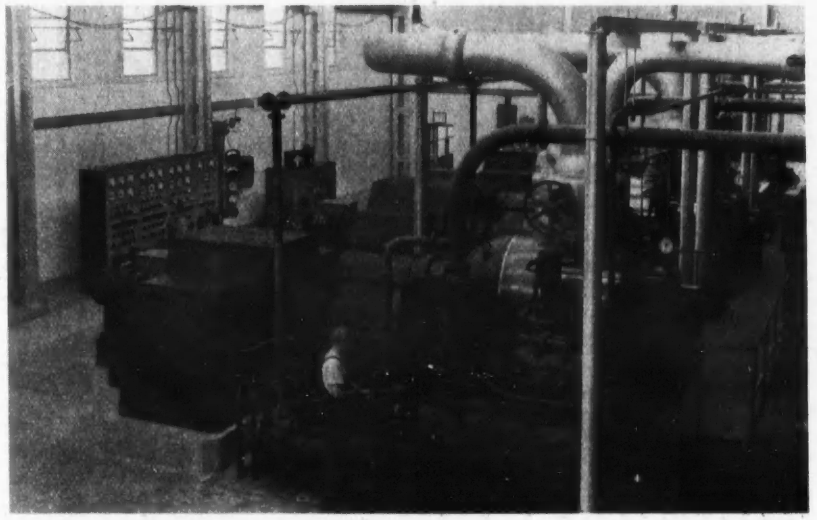
The new factory, which occupies a site of some 45 acres, can be seen in the aerial view we reproduce on page 611. It adjoins the Immingham dock, some 800ft of the quayside of which has been licenced by the firm to accommodate the large ocean-going vessels and coasters bringing raw materials to, and taking finished products from, the factory.

Raw materials are unloaded from the vessels by two 5¼-ton travelling grab cranes with working radius of up to 55ft and a rated capacity of 150 tons per hour. Mounted on the same rails as the cranes are two travelling hoppers into which the cranes dump the materials. The materials gravitate through gate valves in the bottom of the hoppers and fall on to transverse slat conveyor belts which lead into an elevated enclosed gallery 600ft long situated along the inner side of the quay. The slat conveyors deposit the materials into small hoppers which feed down on to a main conveyor belt system leading into the factory. This belt conveyor system which serves the whole plant is some 3500ft long. It was built by Spencer (Melksham), Ltd., and has a peak capacity of 320 tons per hour.

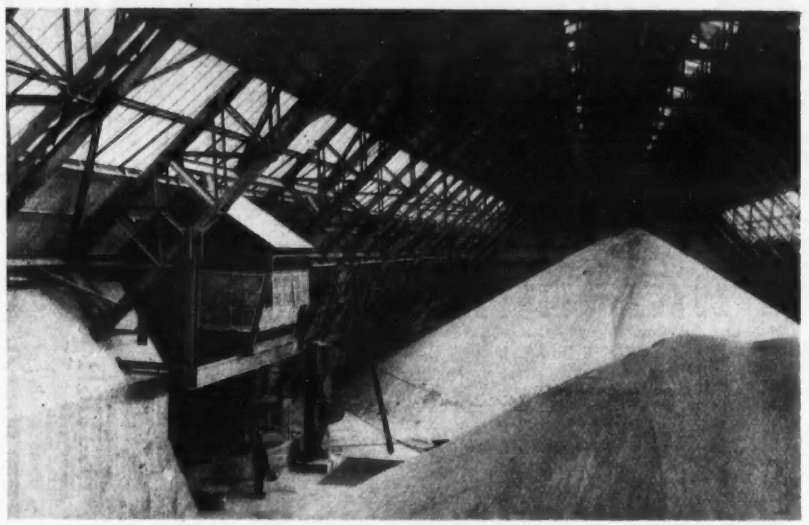
On the same structure as the feed belt system there is arranged, at higher level, a second conveyor belt, which is designed to bring materials in bulk from the finished products store for despatch by water. A tripper can be moved to any required position along this belt to draw the materials off and drop them on to a travelling out-loader with a retractable boom, which can be extended over the hold of a ship at the quayside. Through the outgoing system up to 150 tons of products an hour can be loaded into the hold of a coasting vessel.

The conveyor system takes the raw materials to storage buildings at the end of the factory remote from the dock. The production flow is such that the materials, in processing, work back towards the finished product stores in close proximity to the dock area, where the road and rail loading points are also situated.

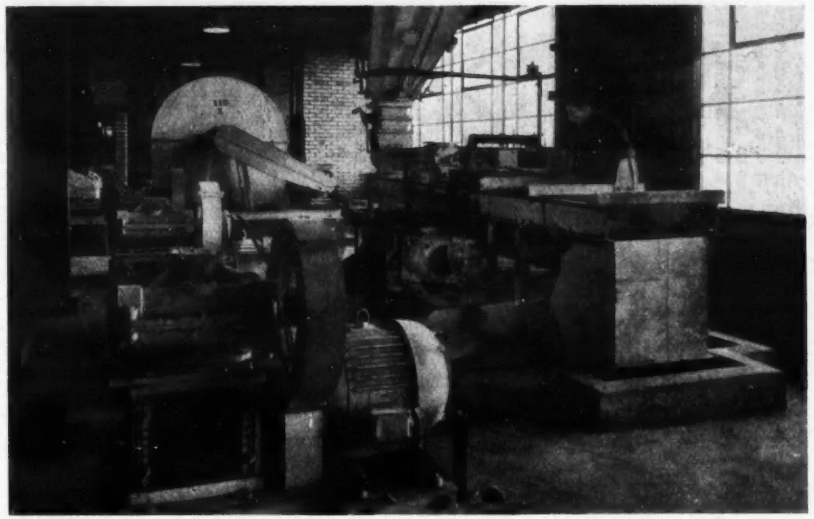
FERTILISER FACTORY—FISONS LTD., IMMINGHAM



TURBINE ROOM



ROCK STORE

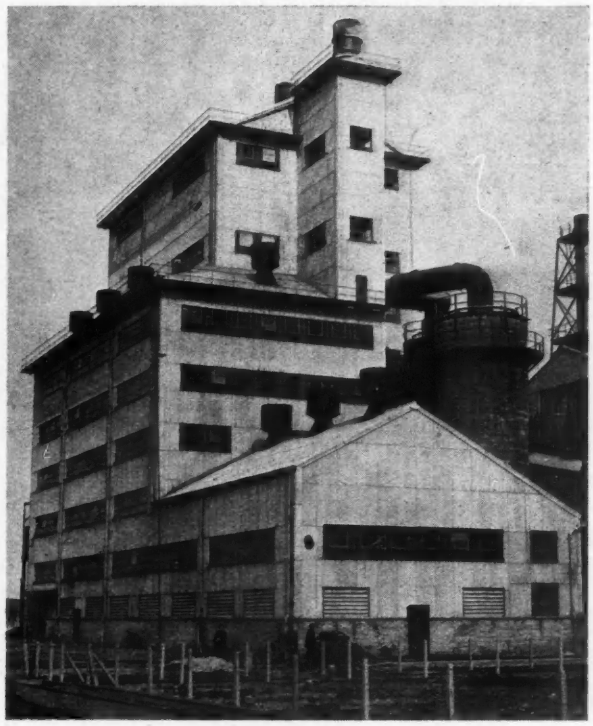


PHOSPHATE AND ACID FEEDERS IN THE PHOSPHORIC ACID PLANT

PHOSPHORIC ACID REACTION EQUIPMENT

There are sixteen main and about thirty subsidiary buildings on the site, together with about 1¼ miles of roadways and 2½ miles of rail tracks. When the buildings were being planned they were arranged to provide straight runs for the interconnecting conveyor belts and allow sufficient space for future extensions. The arrangement was not easily arrived at as the buildings had to be sufficiently far apart to enable conveyors which started their run on the floor of one building to finish up in the roof of another, whilst the gradient of the conveyors had to be limited to prevent the material on them from rolling back on itself. In the interests of economy the buildings could not be too widely spaced and it was stipulated that elevators should be used as little as possible.

FERTILISER FACTORY AREA



TRIPLE SUPERPHOSPHATE PLANT

Before we go on to deal with the plant, buildings and processes at this interesting factory, it should be noted that the first site problem with which the engineers had to contend was the type of foundations to employ. The ground is reclaimed land filled with spoil from the original excavation of the Immingham dock which was constructed early in this century. The top 6ft to 9ft comprises silt and warp, which has little bearing capacity. From 9ft to 30ft deep there is a blue silty warp which also has very little bearing capacity, and which, in addition, has the unfortunate property of behaving as a fluid, the specific gravity of which is about two. This effect had to be very carefully taken into account in designing both temporary and permanent works in connection with deep pits and sumps, as the walls had to withstand this heavy fluid mud pressure and the base slabs had to be designed to withstand the induced upthrust. On account of these site conditions, it was only possible to construct very few small lightly loaded buildings on a raft foundation, and all the rest of the structures had to be supported on piles. Little support could be obtained until a depth of about 30ft was reached and 5750 "Franki" cast-in-situ piles were eventually used.

The power station for the factory is situated in a central position amongst the main buildings.

In its turbine room, shown in one of our illustrations on p. 610, there are three 2190kVA pass-out condensing turbo-alternators built by W. H. Allen, Sons and Co., Ltd. The turbines are designed to take superheated steam at 250 lb per square inch and 700 deg. Fah., and 18,000 lb of steam an hour is passed out by each unit for factory process and heating purposes at 15 lb per square inch. The totally enclosed alternators have built-in air coolers and generate at 6600V, three-phase, 50 c/s; through high-tension switchgear two ring main systems supply the five substations round the factory, in which there are thirteen 500kVA transformers.

Much of the steam required in this power station is supplied from a waste-heat boiler system which forms an integral part of the sulphuric acid plant dealt with later in this article. The balance of the steam is supplied by four Daniel Adamson and Co., Ltd., "Super Lancashire" boilers at 260 lb per square inch and 720 deg. Fah.

In the turbo-generator room there are also accommodated two 7500 gallons per hour feed water pumps, one steam and the other electrically operated, a 75,000 lb per hour de-aerator and three 2000 gallons per minute booster pumps, which boost dock water to a 110ft head, for circulation to the several gas-washing towers on the site and also to the fire hydrants.

The water-treatment plant was supplied and erected by the Permutit Company and comprises a "Spiractor" unit with brine tank and twin filters and chemical pumps and boiler feed conditioning apparatus.

The cooling water for the condensers is supplied to the turbo-generator room from the dock pump-house situated some distance away, by pumps operated by remote control at the central control cubicle in the turbine-house. In the dock-water pump-house are three 4500 gallons per minute Allen vertical-spindle centrifugal pumps which are fed through twin Glenfield and Kennedy rotary screens and automatic float valves.

In this building are also two small debris pumps which pump the debris collected from the screens back into the dock, and two Gwynne surface water pumps, one of 2500 gallons per minute and the other of 1000 gallons per minute capacity. These two units pump all the surface water collected on the site into the dock, but on occasions of excessive flow the collector sump is allowed to overflow into the dock water sump. The cooling water, as it leaves the dock water pump-house, is dosed with chlorine as a protection against mussel growth.

The Manufacturing Processes

For the manufacture of fertilisers sulphuric acid is made from sulphur and part of the output is used in one plant to treat ground phosphate rock to produce the single superphosphate. In a second plant sulphuric acid is converted into phosphoric acid by processing with phosphate rock, and the acid so produced is used for the manufacture of triple superphosphate in a third plant. In a fourth plant part of the output of the single and the triple superphosphate units is mixed with other salts in order to produce compound fertilisers.

The factory uses daily some 250 tons of 100 per cent sulphuric acid and, for its production a Simon-Carves "Monsanto" contact plant burning sulphur, and employing vanadium pentoxide catalyst in a four-pass converter, has been installed. This plant is considered to be one of the largest single-unit contact plants in Europe. Sulphur for the acid plant is deposited by the main incoming conveyor system in an adjoining storage building of 8000 tons capacity. The material is withdrawn from the stock piles by a mobile power shovel and dumped into a melting pit for the first stage in its processing to make the sulphuric acid.

The neat, compact lay-out of this plant, which incorporates sulphur melting and settling pits, sulphur burner, hot gas filter, a waste-heat boiler, converter, economiser, atmospheric gas cooler, drying and absorber towers, acid cooling and dilution system, &c., can be seen in the photograph we reproduce on page 612. A considerable amount of the heat generated in the process is used in the plant itself and also for generating superheated steam, which is fed to the main power station of the factory. All of the instruments required for running the plant are grouped together in a small central control room.

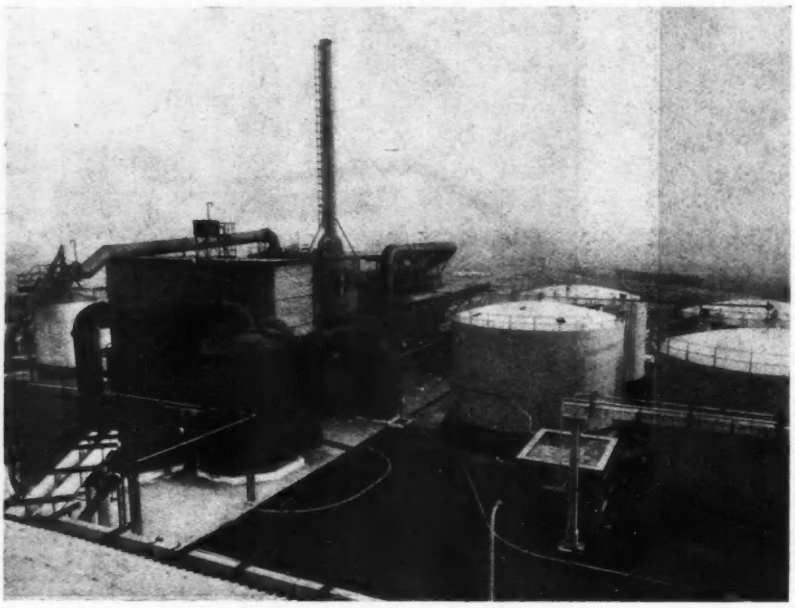
The acid produced is stored at 94 per cent strength in four large tanks having a total capacity of 6000 tons 100 per cent acid.

The phosphate rock store, has a capacity for 20,000 tons of material. It is a three-pin arched structure with a completely unobstructed floor area 360ft long by 110ft span. The rock arrives at the factory

mainly in a lumpy granular form somewhat similar to very coarse sand. It is fed to the store on the main belt conveyor system and deposited on a 36in troughed conveyor belt which runs along the roof peak of the building. This conveyor has a capacity for 320 tons per hour and is fitted with a self-propelled throw-off tripper which, as it moves along, distributes the rock along the length of the building. It is of interest to note that the width and arched shape of the building conforms closely to the natural angle of repose of the phosphate rock pile. By adopting this design, much space and structural material have been saved.

At one side of the floor and partway along the length of the building is the control room for a drag scraper bucket equipment which is used to reclaim the material for processing from the store. This bucket has a capacity of 1250 lb and pulls the rock into a hopper set below floor level which feeds on to an elevator belt. The anchor of the drag bucket is mounted on a carriage which runs on rails round the sides of the floor and is positioned by an endless cable operated from the control room.

The hopper-fed elevator belt leading from the phosphate store carries the material up to the top of the adjacent grinding plant building and deposits into a 200-ton bunker. From this bunker the rock is fed through trunking to 40-ton hoppers feeding each of four "Lopulco" roller mills. Each mill has a rated output of 12 tons of rock per hour and reduces it to a fineness of 80 per cent through a 100-mesh sieve. The mills are air swept by individual fans, and as the rock is fed the air stream picks up the fines and carries them straight through the mills on to the recovery cyclones, leaving the larger material to be ground. Four ground-rock storage bunkers in the building, each of 100 tons capacity, can be fed from any of the mills.



SULPHURIC ACID PLANT

The Superphosphate plants

Through a "Fuller-Kenyon" pneumatic pumping installation of 50/65 tons per hour capacity the ground phosphate rock is fed to a phosphoric acid plant, a single superphosphate plant and a triple-superphosphate plant.

In the Broadfield single-superphosphate plant the ground phosphate is fed from 50-ton hoppers on to a roll feeder, which supplies the material at a controlled rate to a mixer. The crushed phosphate and a carefully controlled amount of sulphuric acid are mixed in the brick-lined paddle mixer before dropping into one end of a den for the curing cycle. This den, which has a capacity of 20–25 tons an hour, consists of a chamber 26ft long, the two longer side walls and floor of which are formed by moving wooden slat conveyors. The mixture falls into one end of the den and during the curing cycle, which lasts about one hour, it is carried by the moving floor and side walls to the opposite end of the den where it drops into a hopper. The finished product is carried away to the stores building by means of a conveyor belt.

Phosphoric acid for triple-superphosphate manufacture is made in a plant operating on the strong acid process and designed by the Dorr Company, Incorporated. It is designed to treat 250 tons a day of ground rock and comprises of three main sections—reaction, filtration and evaporation.

Ground phosphate rock from the main storage bunker is fed by screw conveyors and a metering band conveyor fitted with electronic control, into three mixers arranged in series, where it is mixed with the calculated quantity of sulphuric acid. From the premixers the slurry of rock and acid flows through four agitator tanks in succession to complete reaction. In this reaction stage a phosphoric acid and calcium sulphate mixture is formed.

In the filtration section of the plant the slurry is filtered on Landskrona rotary band vacuum filters, five of which have been installed. On these filters it is washed twice, first with dilute acid and then with hot water. The gypsum residue left on the filter band, which is discarded, is reslurried and pumped away from the factory to a 146 acres site about a mile away. The band filter is divided into three parts so that phosphoric acid in three different strengths is obtained. The first acid is obtained from the direct filtration of the slurry; the second by recirculating the acid wash of the filter cake, and the third, which is returned for the second stage, from the hot water wash. The acid from the second washing stage is returned to the initial reaction section of the plant, where it is mixed with the sulphuric acid before it is fed into the mixers with the phosphate rock.

Phosphoric acid coming from the filtering process has a strength of about 32 per cent, and in a separate evaporation section it is concentrated to 38 per cent in cast lead steam-heated evaporators.

In this plant, some parts of which are illustrated on page 610, the premixers and agitators are enclosed and coupled to a common fume duct to avoid danger from the fluorine gases formed during the reaction between the phosphate rock and sulphuric acid. The gases are passed through a series of scrubbing towers where they are water washed to remove the fluorine.

The seven-storied building erected for the triple-superphosphate plant is to be seen in a photograph we reproduced on page 611. This plant was also designed by the Dorr Oliver Company, and its capacity is 230 tons a day of granular triple superphosphate. Phosphate rock from the crushing section is fed at about 4 tons an hour into reaction agitators. These steam-heated agitators are supplied with proportionate quantities of phosphoric acid.

The acid-rock mixture from the agitators is fed into one of two Blunger units into which the fines from a later stage in the process are also introduced. These units are designed to give a "barrelling" effect to mix and coat nodular particles of the fine dry triple superphosphate with phosphoric acid slurry. They are each some 15ft long and are designed to handle 223 tons of dry triple superphosphate and 16 tons of slurry an hour.

From the Blunger units the mixture drops in a steady stream down a common chute into the head of an 80ft long, 10ft diameter, Newell rotary dryer on the ground floor of the building. This drier is stoker fired and has a capacity of 238 tons per hour. The dried material falls out of the far end of the drier on to a cross belt conveyor leading on to an inclined conveyor, which deposits it into the boot of a bucket elevator. This elevator carries the material to the top of the building and drops it on to a chute feeding four double-deck vibrating screens. In these screens the finished granular from the fines and the oversize materials are separated. The accepted granular triple superphosphate is taken by belt conveyor to the main storage building. The oversize material is chuted to 175-ton bin, whence it passes into pulverisers for feeding back into the system with the fines taken from a storage bin beneath the screens. These fines are fed into the Blungers as already mentioned. A further supply of the fines is obtained from passing the air from the rotary dryer through a cyclone separator and from the material removed from other parts of the plant through a dust-collecting system. An elaborate duct system is laid out to remove gases from all parts of the plant, and these gases are scrubbed in wash towers before being discharged to the atmosphere.

The superphosphates are stored in the building shown in one of our illustrations on page 610. This building is 250ft long, 140ft wide and 58ft high, its storage capacity totalling some 22,000 tons of material. It has bays 60ft wide, 280ft long, separated by a 20ft wide central conveyor bay. Troughed conveyor belts bring the superphosphates and triple superphosphates into the building at roof level. The materials are reclaimed by a combined overhead crane grab and conveyor system. This conveyor system is fed from six elevated hoppers at various points in the building, and it has been laid down to minimise the amount of crane travel over the heaps of stored materials. Each overhead crane has a 68–85 cubic foot grab and is designed to load up to 50 tons per hour into the conveyor hoppers. The cranes hoist at 100ft per minute, traverse at 100ft a minute, and have a longitudinal travelling speed of 250ft per minute. The hoppers are served by 42in witdrawal conveyor belts running at 23·5 feet a minute feeding on two central outgoing conveyor systems.

A 10,000 tons store for the other salts used for making compound fertilisers is fed by overhead conveyors leading from the main factory conveyor feed system from the docks. It has two side bays 60ft span and a centre 30ft span, the bays being divided into 15ft high storage bins. The salts are reclaimed by means of a mechanical shovel and taken by conveyor belt to the compounding plant.

There is also a batching and granulating plant for compounding fertilisers, which was supplied by Edgar Allen and Co., Ltd., It is designed for an output of of 12½ tons an hour, and is conveniently situated adjacent to the superphosphate and salts store.

The primary materials for compounding are loaded into the boots of a series of elevators

either by conveyor belts or mechanical shovels and deposited in overhead bunkers. After having been screened to remove oversized pieces, the materials are batched by weight and mixed in 2-ton Sturtevant mixers. The mixture is then passed for granulating through a 21ft long rotating conditioner where water is added. From the conditioner the mixture falls in granulated form into a 57ft long coal-fired rotary drier and, following subsequent screening, is passed through a cooler and out to storage. Oversize material rejected by the screens is broken down in a chain beater disintegrator and returned to a previous stage in the cycle.

For storing the granular compound fertilisers a building 320ft long and 140ft wide, with a capacity of 20,000 tons, has been erected. As with the other stores it is fed by overhead belt conveyors, the compounds being recovered by overhead crane grabs and dropped into hoppers feeding the belts.

A large bagging plant building has been sited between the two stores, for the primary phosphate fertiliser, and the granular compounds.

Finished products are brought into the bagging building by three conveyors on one side and two on the other. On arrival in the building the materials are delivered either to bulk despatch hoppers or to the bagging plants. Two such units have been installed and space is provided for the installation of two more in the future. Each of the bagging units has an output of 500 1-cwt bags per hour.

The main bagging plant floor is constructed at a high level so that the materials can be loaded by gravity through chutes, directly into road lorries, or rail trucks. There are three railway tracks and two roads of ample width which permit several combinations of loading to proceed at the same time. Long platforms, between the rail tracks, on one of which a weighbridge is installed, provide facilities for the control of loading operations.

The bagging plant has been largely mechanised, the material being fed down in measured quantities from overhead hoppers into bags held up on a conveyor. After filling, the bags are moved a short distance along the conveyor to be closed on a stitching machine, whence they pass on to the gravity chutes leading down to the loading bays below, or are placed on pallets for storage. It is of some interest to note here that in the filling, stitching and actual loading of bags on to vehicles, this is the only point in the plant where manpower is directly used to handle loads, and even then to a very limited extent.

In addition to the main process buildings, the factory has large well-equipped workshops in which there is a main machine shop, 120ft long by 40ft wide, with a full complement of the usual machine tools. Leading off the main machine bay are small workshops for the electricians, plumbers, carpenters, &c.

An administrative building incorporating the main offices and the laboratory is a two-storey, steel-framed structure with a flat, reinforced concrete roof. The well-equipped laboratory is fitted with special teak benches and cupboards, and a plenum ventilation system is installed.

In the canteen building there are three dining halls, one to seat 200 operatives, another to seat thirty administrative staff, and the third for private use. All three are served from one centrally placed, well-equipped kitchen fitted with electric ovens, steam boilers and hot plates.

Special attention has been paid to the welfare facilities for the operatives, and the ablutions section includes shower baths, clothes lockers and clothes-drying rooms. A well-fitted medical centre is also provided.

In laying out this new plant the experience acquired over many years of fertiliser manufacture by Fisons, Ltd., has been used to full advantage, and much of the work has been done in close co-operation with the Dorr Company. To carry out the engineering side of the project the company appointed Sir Alexander Gibb and Partners, and Messrs. Maunsell, Posford and Pavry as joint consulting engineers.

A Dual Capacity Goods Lift

THE difficulties of designing a goods lift capable of raising heavy loads at slow speed and lighter loads at higher speeds are believed to have been solved in the dual capacity goods lift made by the Express Lift Company, Ltd. In the dual capacity lift the attendant can make the change between heavy and light running conditions without leaving the lift car. The equipment is designed to raise loads of 2 tons at 150ft per minute or 5 tons at 50ft per minute, the counterweight being arranged for the maximum load of 5 tons.

For normal working, that is, for lifting 2 tons at 150ft per minute, a weight of 1½ tons is carried beneath the car in a specially developed release mechanism. To balance the lift for loads up to 5 tons this weight is deposited in a cradle at the bottom of the lift pit. To do this the attendant takes the car right down to the pit. He then withdraws a trap in the car floor and moves a small lever, which operates the release mechanism. Thus the complete changeover from one capacity to another is carried out within the car.

The system is fully electrically interlocked to ensure that the weight carried beneath the car cannot be released unless the lift car is at the pit bottom, that the lift cannot start unless the release mechanism is properly reconnected and that the lift cannot run at the higher speed (150ft per minute) unless the weight is in position under the car. The lift itself is operated on the "Trulevel" power system, which is varied to suit the dual capacity operation. The levelling system operates with both lifting capacities, the lift stopping from a levelling speed of 12ft per minute. Two motors are used, a single-speed squirrel-cage motor and a two-speed pole changing motor. The single-speed motor is permanently connected to the wormshaft, but the pole changer is connected to the "Trulevel" clutch. The single-speed motor provides full speed running for 2 tons at 150ft per minute. The high-speed winding of the pole changer provides full speed running for 5 tons at 50ft per minute capacity and the slow-speed winding of the pole changer provides the levelling speed for both capacities.

I.E.E. Faraday Medal

THE Faraday Medal for 1951 was presented to Dr. Thomas Lydwell Eckersley on Tuesday, May 1st. Because of illness, Dr. Eckersley was prevented from receiving the medal in London and the presentation was made at a private ceremony held at the Chelmsford works of Marconi's Wireless Telegraph Company, Ltd. In making the presentation, Sir Archibald Gill, President of the Institution of Electrical Engineers, said that the Council of the Institution had made the award to Dr. Eckersley to acclaim his achievements in radio research and, in particular, for his outstanding contributions to the theory and practice of radio wave propagation.

At the presentation Sir Archibald was accompanied by two past-presidents of the Institution, Professor E. B. Moullin and Sir Noel Ashbridge, and Mr. W. K. Brasher, Secretary of the Institution. Mrs. Eckersley and several of Dr. Eckersley's personal friends, with a number of his former colleagues, were present, together with Sir George Nelson, chairman of the Marconi group of companies.

Among Dr. Eckersley's outstanding achievements have been his prediction of the performance of short wave services, including the enunciation of a theory of the diffraction of waves round the earth, taking into account the earth's resistance and the application of phase integral theory to propagation problems. By another method he produced a theory of propagation in the ionosphere and his experiments in connection with the interpretation of random echoes from the ionosphere led him to his now well-known theory of scattering. He was also the first to employ the method of spaced frames to achieve a direction-finding system substantially free from polarisation errors. Dr. Eckersley has presented many papers before the Institution and has been awarded many Premiums, including the Duddell Premium (four times, in 1922, 1927, 1929 and 1932) and the Kelvin Premium (in 1940). In recognition of his contributions to the understanding of radio wave propagation, Dr. Eckersley was elected a Fellow of the Royal Society in 1938.

Machine Tools for the Defence Programme

THE Minister of Supply, Mr. G. R. Strauss, announced on Tuesday last that a cut of about 35 per cent in the deliveries of machine tools to home civilian users in the next eighteen months was likely to be needed to meet the requirements of the defence programme. He said that in order to ensure that the cut, severe though it was, did the least harm to civil industry, regional panels were to be set up to advise on methods of reducing or deferring the demand for tools. Representatives of the panels would visit civilian users' works to examine how pressing was their need to install machinery which they had on order, but which was now urgently needed for the defence programme. Those representatives would, for example, in consultation with the user, suggest substitution of machines in easier supply, the more effective use of existing plant, and the deferment of delivery of machines against the company's replacement programme.

Mr. Strauss stated that the scheme had the support of the Engineering Advisory Council and the Machine Tool Advisory Council. Arrangements had been made to provide the Ministry with detailed schedules of proposed deliveries by United Kingdom machine tool makers. On present estimates, the Minister continued, the £4,700,000,000 defence programme called for 35,000 extra machine tools, of which it was hoped to get 19,000 to 20,000 from overseas. Orders had already been placed abroad for more than 18,000 machine tools, which number included 6650 from the U.S.A., 3150 from Western Germany, 1862 from France, 1550 from Italy, 1770 from Switzerland, 1041 from Belgium, and small quantities from Sweden and Denmark. The remainder—from 15,000 to 16,000—must come from the British machine tool industry. Orders by defence contractors had been placed in the normal way with United Kingdom makers for about 8000 tools, which meant that from 7000 to 8000 must be obtained over the next eighteen months by diversion from existing customers. The kinds of machine tools needed, Mr. Strauss explained, were at present taking from two to four years to be delivered. The abnormal load arising from the defence programme would mean a substantial cut in home civil investment in machine tools, the extent of which would vary between classes of tools and between different sectors of the engineering industry.

The Minister went on to say that the six regional panels to be set up—in London, Coventry, Birmingham, Manchester, Halifax and Glasgow—would cover the same areas as the existing regional production efficiency panels of the Machine Tool Trades' Association. The chairmen of the panels would be machine tool makers, each panel consisting of twenty-five experts drawn from the machine tool industry and the Institution of Production Engineers. When the Ministry needed advice on a problem connected with the installation or use of machine tools, the chairman of the appropriate panel would select the technical experts best qualified to advise on the particular case. They would discuss the problem fully with the person or firms concerned and would report to their chairman. He, in turn, would send their report, with his comments, to the Ministry. The panels would work in co-operation with the Regional Controllers of the Ministry of Supply.

Mr. Strauss ended his statement by asking the engineering industry to exercise self-denial and restraint in attempting to acquire new tools, and to accept voluntarily the setting back of orders. Little relief, he said, could be expected from the curtailment of export orders, although they would be examined. Most exports went to the Commonwealth and to the North Atlantic Treaty Powers for the common defence effort or for their own essential needs.

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RAW MATERIALS

TWELVE months ago the industrial production of Western European countries and of the United States was increasing annually at a rate of 8 to 10 per cent. The draft upon raw materials was, of course, similarly increasing. It is true that some evidence then existed that the demand for certain materials was beginning to outrun supply. But there was no reason to believe that any scarcity which might develop would become acute. Indeed, an impression was widely current that, assuming the cold war grew no warmer, prices of raw materials were more likely to fall than to rise. Certainly the Government of this country seems to have held that opinion. For its buyers tended to hold off the markets waiting for prices to fall. In the debate on the Defence Programme (Raw Materials and Production) in the House of Commons last week, the Opposition blamed the Government for its lack of foresight. Perhaps it was right to do so. For Governments must be held blameworthy if they make mistakes. But what happened in the past is a matter of political rather than of technical importance. What engineering firms want to know is what is happening now and what is to happen in the immediate future. How great are the shortages of raw materials likely to become? To what extent are substitutes going to be available? How scarce are materials to be allocated? The debate did not illuminate those questions.

Undoubtedly the resignation of Mr. Bevan and Mr. Wilson shook what confidence the country had in the ability of the Government to ensure that sufficient raw materials would be available to maintain the existing rate of production. For the engineering industry is already very well aware how difficult it is to obtain certain scarcer materials. Mr. Bevan, moreover, in his resignation speech, was categorical. "It has for some time," he said, "been obvious to the members of the Government and especially to the Ministers concerned in the production departments, that raw materials, machine tools and components are not forthcoming in sufficient quantity, . . . and that, therefore, the figures in the Budget for arms expenditure are based upon assumptions already invalidated." He referred to the £4700 million arms programme as "already dead." Nor was the answer given by Mr. Strauss in the debate last week at all complete. He was reassuring about machine tools. Some 14,000 to 16,000 needed for the defence programme are to come from home production, of which about half have already been ordered. Another 8000 are to come from Germany. Orders for 6500 machines have been placed in the United States and U.S. Government priority rating for 4500 of those machines has already been obtained. Given that that priority holds against the demands for the U.S. Service Departments, the machine tool situation should therefore prove satisfactory. Further details of machine tool orders were given in a statement published last Tuesday and printed on another page of this issue. But machine tools are of little use unless materials are available for them to work upon. On that matter Mr. Strauss could do no more than point out the obvious, that certain metals and certain ferro-alloys are already in severely short supply, and to refer to the fact that "discussions are continuing at Washington in the International Commodity Groups, and although progress has been rather slower than we would have liked, discussions are proceeding which we still hope will lead to early and fruitful decisions." He also reminded the House of a statement made by Mr. C. E. Wilson, the American Director of Defence Mobilisation, that the United States must recognise that it must devote some of its resources "to sustaining the strength of allies so that we might collectively enjoy the benefits that this free world would derive from that strength." Industries would have been more content to have been given figures of percentages of former supplies likely to be available to them in future. At present they have little but guesswork to work upon in planning future operations.

In this situation there seems to us to be at least one encouraging factor. The shortages of raw materials have developed relatively suddenly. They developed and began to grow more acute soon after the war in Korea began. But twelve months ago the productive machines of Western Europe and America were already running nearly "flat out." There was little scope for any immediate increase of output. Nor do we think that, even in America, there has since been any really abnormal increase in the rate of output over and above the natural annual increase. It follows—for a natural increase in output of raw materials has also occurred—that the real demand for raw materials for immediate use cannot in these last twelve months much have exceeded the supply. The shortages have, in reality, been brought about by stockpiling by individual firms and Governments. In fact, Government programmes for increased arms production cannot immediately affect output. Productive capacity grows slowly. The announcement of such programmes, however, may frighten firms into a belief that shortages are pending, and thus, through the influence of stockpiling, bring about the very shortages that they stand in fear of. In these circumstances, and providing that Governments in general and the U.S. Government in particular can control the economies of their respective countries, it remains possible to believe, as our Government believes, that Mr. Bevan is wrong; that the present acute stringency will not be prolonged; and that the Western nations, by agreement among themselves, may be able, shortly, to ensure that each shall get supplies adequate to maintain its production at reasonable cost.

RAILWAY SPEED

IN Great Britain, where the steam locomotive was invented and the earliest railways were constructed, there has always been a naturally jealous regard for the prestige of British railways. As other, and larger, countries followed our initial lead and duly worked into their respective strides it was inevitable that some of the more spectacular feats of operation should be claimed by foreigners, since the mere geographical limitations of these islands prevented us from making through journeys of more than some 600 miles in length. But although there were times prior to 1914 when the blue riband of railway speed seemed to have slipped from our hands, the point was not beyond argument, and in standards of locomotive performance the Great Western, under Churchward, and the London and North-Western, under Bowen-Cooke, could challenge comparison with anything in the world at that time. Furthermore, after the dislocation caused by the First World War, Britain, despite the burden of traffic carried by her railways, was quicker than either France or the U.S.A. to restore pre-war speed. In 1923 there were ten British runs timed at 60 m.p.h. or slightly over, whereas France and America could not then produce a single one between them. From 1932 onwards a very high standard of express passenger train service was developed in this country, and although in both mileage and maximum booked speeds we were surpassed by America, the facilities offered to the public and the standard of punctuality maintained were alike excellent. In August, 1939, an aggregate daily mileage of 12,016

was booked to be run at start-to-stop average speeds of 60 m.p.h., to which total the L.M.S.R. contributed 6902 miles, the L.N.E.R. 2896, the Great Western 2187, and the Northern Counties of Ireland 31. At 58 m.p.h. and over the aggregate reached the remarkable total of 18,717 miles.

It is with all the greater pang that we recall this splendid record at the present time, when, nearly six years after the end of hostilities in the Second World War, Great Britain has been completely outstripped in the realm of railway speed, not only by America, but by France too! That France should have so recovered from the effects of enemy occupation and the havoc caused by Allied bombing as to be able to schedule a daily aggregate mileage of 17,695 at 58 m.p.h. and over in the summer of 1950, while we, at the same time, could not manage more than 352 miles, is astounding, to say the least of it—all the more so in that the British aggregate was made up of eight runs, all over the 44-mile stretch between Darlington and York. Some of the factors contributing to the present eclipse of British railway prestige are discussed in an article on page 608 of this issue. The causes are admittedly complex, and some of the arguments put forward in attempted justification of the present moderate performance are indeed cogent. It is disquieting to realise that on some stretches of important main line scarcity of labour is causing a deterioration in standards of maintenance of the track, and the consequent imposition of speed restrictions, while in other parts of the country the scarcity of labour for shed duties is reacting upon the condition of locomotives regularly drafted to important duties. At the same time, one cannot disregard the psychological effects of amalgamation. The greater the merger the greater the upheaval, and in this connection we have the most vivid memories of early "grouping" days on the L.M.S.R., by far the biggest of the "big four," and containing such strongly individualistic concerns as the London and North-Western, the Midland and the Lancashire and Yorkshire. Add to the natural upheaval of amalgamation all the difficulties of the present time, in housing, short rations, the natural aftermath of a ferocious war, and the political bitterness that marked the passage of the Transport Act of 1947, and the circumstances will not appear favourable for a rapid restoration of high-speed passenger service, which requires, above all, good team work between all the railway departments concerned with operation.

Yet withal the prospect is not so entirely gloomy as it might appear. In certain parts of the country full pre-war standards have been restored. Since the end of the 1950 summer service the Scottish Region has introduced 60 m.p.h. bookings on the former Caledonian line; the North-Eastern Region is quite a model, for fast running, smartly-kept locomotives and punctual service, and one could point to other places where there is ample evidence of keen attention to the needs of the public. At some of the Glasgow running sheds pride in the job has revived the old Caledonian custom of enginemen applying little decorative touches of their own to locomotives that they share regularly with one or two other crews. What can be done in one district, or indeed one Region, can be done elsewhere if strong, understanding and imaginative local leadership is forthcoming, and is allowed a reasonably free hand. There must be, we suppose, a measure of standardisation, but it is plainly evident that where local initiative is flourishing there the best results are to be seen. As with locomotive operating, so with permanent way maintenance. We know of one stretch of cross-country line where the territories of two of the pre-nationalisation companies adjoined; the line ran entirely through rural country, yet the maintenance on one company's line was as good as on the other's it was bad. After three years of nationalisation the comparison still holds, if anything more strikingly than ever, yet there can be little, if any, difference in the availability of labour locally. Taking the country as a whole, the present standards of speed are not merely inadequate; they are unworthy of the British railway system. Numerous individual runs on all routes show quite clearly what present-day locomotives can do; we hope that before long these capabilities will be put to better purpose.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

FLOW OF WATER IN RIVERS AND CANALS

SIR,—It would appear that Leliavsky Bey, in the opening paragraphs of his most interesting historical paper on the flow of water in canals and rivers (THE ENGINEER, April 13th, page 466) has inadvertently charged Galileo with another fallacy. The balls A and B in his Fig. 2 will reach the ends of their courses with equal velocities but not simultaneously. It was subsequently clear that Leliavsky Bey was thinking of the equality of velocities, but it might be remarked that the time of descent of a particle under gravity starting from rest and following a continuously curved smooth path in a plane of inclination β is given by

$$T=\frac{1}{\sqrt{2g}\,.\,\sin\beta}\int_0^L\sqrt{\frac{1+(dy/dx)^2}{x}}\,.\,dx$$

if the curve of the path is taken as $y=f(x)$ with axes in the plane and the Y-axis horizontal, L being the length of the shortest straight line down the plane. It follows that the time increases with deviation from the straight, the more so as the deviation occurs early in the run.

R. G. FRECHEVILLE

Sheffield, May 6th.

PRESENT-DAY LOCOMOTIVE WORKING IN GREAT BRITAIN

SIR,—It is indeed refreshing when reading Mr. Nock's latest article on locomotive performance, to realise that one Region of British Railways, in continuing its pre-nationalisation building and operating policies, has perpetuated such efficient locomotives, which are, furthermore, operated so near to their maximum efficiency.

It is interesting to compare the figures given by Mr. Nock with some others published during the autumn in THE ENGINEER. On the train chosen for the interchange trials between St. Pancras and Manchester, the coal consumption of the Class "5" locomotive used could be reduced by over 5 cwt, if the overall timing of 4 hours 22 min. were reduced to the even 4 hours. A similar saving of all but 2 tons of coal per week on every locomotive in the class would have gone a long way towards meeting the recent target figure of 10,000 tons per week, without recourse to any suspension of passenger-train services.

Recently it was reported that the engines of the L.M. and Scottish Regions have the highest coal consumption of any region. In the latter region climatic conditions are partly responsible for the high figure, although roughly half the locomotives in service in the Region are of L.M.S. origin. It may well be that in the case of the L.M. Region the locomotives are not being operated at their maximum efficiency.

Alternatively, the high coal consumption on the L.M. Region may, in part, be due to certain features in the design of their locomotives. Consequently, it would be interesting to see how the coal consumption on the Western Region of the Class "FMT Pacifics," which follow very largely L.M.S. practice in design, compares with that of the "Castle" class, and also to compare the coal consumptions of some standard class when in service on both the L.M. and Western Regions.

One hopes it is realised in the right quarters that maximum efficiency is not achieved at minimum speed and that, if all locomotives were operated at their maximum efficiency, large savings in time would result, with a consequent improvement in the facilities offered to the travelling public.

PETER W. B. SEMMENS, B.A.

Middlesbrough, May 2nd.

BOOKS RECEIVED

Capacitors for Industry. Edited by W. C. Bloomquist. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 36s.

Glass. By J. Home Dickson. London: Hutchinson's Scientific and Technical Publications, Stratford Place, W.1. Price 25s.

Supply of Water. Second edition. By T. H. P. Veal. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 25s.

Engineering Hydraulics. Edited by Hunter Rouse. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 120s.

Radio Technology. Third edition. By B. F. Weller. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

Theory of the Interior Ballistics of Guns. By J. Corner. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 64s.

Trigonometry. By A. Page. London: The University of London Press, Ltd., Little Paul's House, Warwick Square, E.C.4. Price 18s.

Transmission Lines and Filter Networks. By John J. Karakash. London: MacMillan and Co., Ltd., St. Martin's Street, W.C.2. Price 45s.

Directory of Shipowners, Shipbuilders and Marine Engineers, 1951. London: Tothill Press, Ltd., 33, Tothill Street, Westminster, S.W.1. Price 30s.

Electromagnetic Waves and Radiating Systems. By Edward C. Jordan. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 32s. 6d.

How to Write Technical Books. By John Gloag. London: George Allen and Unwin, Ltd., Ruskin House, 14, Museum Street, W.C.1. Price 12s. 6d.

Elementary Theory of Structures. By J. C. Grassie. London: Longmans Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 25s.

Directory and Buyers Guide

THE 1951 edition of the Engineer Directory and Buyers Guide has just been published and one free copy is being despatched by post to all subscribers on our lists. Arrangements have also been made for all regular readers of THE ENGINEER who obtain their copies through newsagents to receive a copy, which should be delivered to them with the current issue. Any subscriber or regular reader not receiving a copy should write to The Manager, THE ENGINEER, 28, Essex Street, Strand, London, W.C.2. Extra copies are obtainable at 2s. 6d. each, including postage, and a form for ordering them is enclosed in this issue.

Literature

Mechanical Vibrations. By W. T. THOMSON. London: George Allen and Unwin, Ltd., 40 Museum Street, W.C.1. Price 15s.

THERE are many books on the elements of mechanical vibrations available to the student and the designer and any addition to the number should either present the elements in a different way, which is more attractive or more easily understood or, on the other hand, should include a wider range of the background knowledge. Otherwise the student may well feel bewildered by the choice between so many textbooks all appearing to him to be very much the same.

The volume under review falls somewhere between a repetition of other books and an extension of them in certain divisions of the subject. In the early chapters it follows the well-worn channels recognisable at once to the engineer who has dipped into the subject from time to time. The introductory chapter on simple harmonic motion, and Fourier's series, the chapter on undamped free vibrations with a single degree of freedom, and Chapter III on damped free vibrations, contain nothing new and many of the problems set at the end of each chapter are old friends. The subject matter of these three chapters is treated with a minimum of explanatory matter although the style is very good. They reflect clearly the "lecture" origin of the book.

In the next chapter—on forced vibrations with a single degree of freedom—the author appears to get into his stride and this section of the subject is excellently treated. The interpretation of the governing equations is very good and is taken further than will be found in most other comparable textbooks. The paragraphs on balancing could well have been extended, the descriptions of balancing machines being quite inadequate. The same remark applies to the section on vibration-measuring instruments, where the details of the electronic and other vibrometers are disposed of in six pages. The electric resistance wire strain gauge is referred to by the unusual title of metalectric gauge: the information given—in about 250 words—is so sketchy as to be almost misleading. The author may have argued that he was writing a book on the elements of vibrations theory and that practical and technical details were out of place. If this was indeed the intention, it would perhaps have been preferable to have omitted these sections or, alternatively, to have given a few references to reliable sources of information. The problems at the end of this chapter are very good and many of them appear to be entirely new.

The next chapter deals with systems with two degrees of freedom. This chapter, although again very condensed, is good, and some practical illustrative problems are worked out in detail. The treatment of systems with many degrees of freedom is skilful, but some sections could profitably have been enlarged; the energy method and Rayleigh's method are far too briefly sketched to give the student a firm grasp of the techniques involved. Holzer's method, the graphical solution for a beam with several concentrated loads, the iteration method, Dunkerley's equation, Burgess's method for fundamental frequencies of cantilevers and Myklestad's method are all outlined in this chapter. The next chapter presents a short account of the vibration of elastic bodies.

The book ends with a brief reference to the electro-mechanical analogy and to the use of the similarity principle.

Taken as a whole, the style and orderly presentation are admirable. The author has clearly had much experience in making the subject intelligible. It is felt, however, that he has held too closely to his lecture notes, and the explanatory and illustrative matter could have been advantageously expanded. As it is, the book can be recommended to the student as a reliable and authoritative work for reading in relation to a course of lectures on mechanical vibrations. By itself it may prove too condensed for easy reading by those who have no previous knowledge. The author's clear and lucid style would have allowed him safely to have explored the by-ways of the subject rather more fully, without fear of losing his way in a mass of detail.

Atomic Energy for the Layman. By Sir A. L. DIXON. London: Chantry Publications, Ltd., 63, Neale Street, W.C.2. Price 8s. 6d.

THIS excellently illustrated little guide book is intended primarily for the information of the Fire and Police Services of this country, over whose administration at the Home Office Sir Arthur Dixon presided for the latter part of his official life. That experience, following his early graduation as a wrangler at Cambridge, has qualified him to undertake a wide survey of the many problems raised by the release of nuclear energy. Fortunately for his readers, he possesses the gift of writing concisely and simply, and there is little doubt that those who will take advantage of his instruction, and they are likely to be many, will be drawn from a far wider circle of readers than the specialists at which he particularly aims.

Although in his first chapter he makes it clear that he has drawn largely on professional talks and articles of his own already published elsewhere, there is no sign in the book of any lack of continuity in treatment or purpose. Of its couple of hundred pages about a third are devoted to a simple account of the physical theory which underlies the work; this is followed by as much again on the nature of the atom bomb itself; and the rest to the possible civil uses of atomic energy, the problem of civil defence and the so far entirely abortive attempts to solve the vexed question of finding an agreed method for international control. Apart from this last question, the author does not attempt to discuss the moral, social, political and military challenge put to humanity by these recent discoveries and technical attainments. Nor does he forecast the ways in which an aggressor armed with a stock of atom bombs would be likely to attempt to use them for attack.

The damage done when such a bomb explodes arises in part from the intense pressure wave which is created, partly to the resulting flash of light and heat, to radiations of higher frequency such as gamma rays, and to any induced radio-activity. Usually it will be caused by a combination of them all, but fortunately the pressure wave travels so much more slowly than the flash, that shutters to windows often suffice to protect the contents of a room from being set on fire by the flash, although the shutters may be shattered by the following pressure wave. The author's description of these matters is clear and simple, though briefer than some would desire. But those who need more can easily get it from the modestly-priced pamphlet recently issued by the Home Office Civil Defence Department (No. 6/1950), entitled "Atomic Warfare." The author explains the official attitude to civil defence measures against the atom bomb as based on the consideration that such an attack need not necessarily be overwhelming and that it would be a grave mistake to give up all attempts to mitigate the consequences that would follow an atom bomb explosion whether in a city area or in open country. Whatever the degree of destruction and whatever the difficulties in the way of rescue work or fire-fighting activities at the centre of the area, there must always be a periphery in time and space where there will be people in need of succour and fires to be fought.

The author is naturally cautious in his forecasts of future developments, but he does warn his readers that if the experimental types of atom bomb used against Japan could have been so contrived as to make use of the whole of the energy stored in the fissile material they carried instead of only a very small fraction of it the explosive energy let loose would have been increased a thousand fold or more. And if it seems fantastic to have to face the possibility of even more destructive bombs being made than those then used, one must remember that there lies ahead the conceivable utilisation some day of elements at the lighter end of the periodic table, such as hydrogen, helium or lithium, which unfortunately might lead to the creation of just that very "fantasy." Luckily, however, as things are, we are likely to have at least some breathing space before that day arrives—if ever it does.

The Identification of Molecular Spectra, By R. W. B. PEARSE and A. G. GAYDON. Second edition. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 50s.

THIS is a practical book for experimental spectroscopists especially interested in research in band spectra. From this point of view the book is logically arranged. After the introductory pages thirty-six pages are devoted to a table of persistent band-heads, which serves as a wavelength index to the individual band systems described in detail in the following 210 pages. The investigator who photographs a band spectrum which he does not recognise may measure the prominent band-heads and then seek them in the table. This enables him to find if these bands are included in the detailed description of individual band-systems. The plates aid in identifying the commoner bands by providing well-reproduced photographs of sixty-five band spectra.

In the detailed descriptions the different systems of bands are separately described, with copious references. Under each system, where known, are described the occurrence, appearance and the transition involved. The intense band-heads are listed and when they are known, the vibrational quantum numbers belonging to each head are given.

The book contains a mass of information, containing fresh data up to as late as November, 1949. It is, in consequence, likely to be helpful to theoretical spectroscopists as well as to experimental ones and it would have been still more helpful to them if the series formulæ could have been given for those systems where they are known. Since, however, the book is primarily intended

for the experimenter, this is not a serious shortcoming; it would have made the book longer and have thrown an additional burden on the authors, especially if they had attempted a critical selection of series formulæ when alternatives are offered.

The book ends with a chapter of practical hints and an appendix containing a few useful data.

The first edition was published in 1941 and the new edition is considerably enlarged, due to the large number of papers which have appeared in the interval. Serious workers in this field must have access to this book, and most will wish to have their private copy.

The Mathematical Theory of Plasticity. By R. Hill. Oxford: The Clarendon Press. Price 35s.

CIVILISATION has been dependent upon man's knowledge of and skill in the shaping of metals for many hundreds of years, but it is only very lately that the craftsman's abilities have needed supplementing by a deeper insight into the mechanism of plastic deformation. When it is also remembered that most of the mechanical tests laid down in specifications and standards for assessing the qualities of metallic materials refer mainly to the plastic behaviour of the materials, it is surprising that a complete theoretical interpretation of plastic phenomena has only been attempted in the last thirty years.

The study of plasticity has been approached principally in two ways: the mathematical theory, on the one hand, deals with idealised materials and has as its object the development of mathematical techniques for calculating non-uniform distributions of stress and strain in plastically deformed materials; the experimental approach attempts to relate the behaviour of polycrystalline aggregates to fundamental knowledge of single crystals, and to use experimentally determined laws and criteria to predict technically important results.

Dr. Hill's book deals with the former approach and the first three chapters, in which he sets out the general theory of plasticity, are an excellent statement of the present position. He has made use of the tensor notation throughout these chapters, and while the notation must, of course, be dropped as soon as the application of the theory to individual problems is considered, it, nevertheless, leads to a succinct and convenient statement of the fundamentals.

In the later chapters, Dr. Hill has dealt with the applications of the theory to a wide range of problems and metal-working processes, starting with the solution of problems in the elastic-plastic range—that is, where the plastic region does not extend throughout the whole mass of the material but is largely confined within an elastic boundary. The autofrettage process is typical of such problems, which are mainly axi-symmetrical and involve plastic strains of the same order as the elastic strains.

Plane plastic deformation is considered in the next chapter, which contains the first complete statement of the theory of the slip-line field, a development of great importance, which owes much to a group of mathematicians (of which Hill was one) at the Armament Research Establishment during the last war.

The next four chapters outline the application of plasticity theory to metal-working processes, in which plane strain conditions largely exist. Hill divides the topics into steady motion problems—that is, problems in which the stress and strain rate at any point are constant—and unsteady state problems—that is, problems in which the plastic deformation modifies the boundary condition and leads to a changing stress and strain rate at any point. The book ends with a chapter on plastic anisotropy.

Complete agreement has not as yet been reached as to the fundamental statement of the rules of plasticity. That is as it should be in the early years of any new science, but the technologist who is interested in the subject needs detailed and critical comment of the points of difference between the contrasting theories, and in this respect the undoubted value of Hill's book could have been further enhanced. While he has commented on some aspects of the subject matter where there are differences in approach or conclusion he has contented himself in the main with footnote references to divergencies in the published literature. It is, perhaps, natural that in the later chapters considerable prominence has been given to his own numerous papers.

Management in the Smaller Office. London: British Institute of Management, 8, Hill Street, W.1. Price 6s. 3d.

ACCORDING to the foreword, "This booklet is addressed primarily to the general manager of a business employing an office staff numbering between twenty and seventy." It is indeed a worthy attempt to set down in a logical manner all those activities carried on by the various departments of an office. But it is hardly conceivable that a general treatment of such a detailed subject will really be of much value to a general manager, who could hardly have attained his position without such rudimentary knowledge as is offered in this book. The successful organisation of an office is largely a matter of common sense and the application of essentially simple techniques to the particular circumstances of the business. Where more complicated techniques, such as machine accounting, are called for, advice is readily available from the various companies who specialise in such equipment.

British Purchasing Commission to Europe

THE Minister of Supply, Mr. G. R. Strauss, announced on Tuesday that the Government had decided to set up a European Purchasing Commission, which would be under his direction. The organisation would encourage the procurement in Europe of stores and equipment required for the United Kingdom's defence programme. It was felt that by placing orders in Europe to supplement production in this country mutual benefits would result. European countries of the North Atlantic Treaty Organisation and certain other countries included in the European Economic Organisation would be helped to develop their own capacity to fulfil the defence programmes and their balance of payments and general economy would benefit.

The work of the Commission, Mr. Strauss said, would also enable British manufacturing capacity to be used for essential home production and exports to a greater extent than the substantial rearmament programme would otherwise permit. The Commission would operate in Europe for all Government departments concerned in the defence programme and would be ready to advise manufacturers who might wish to place sub-contracts in Europe. Sir Donald Perrott is to be chairman of the Commission, with Captain K. J. G. Bartlett as deputy chairman. They would be assisted by an advisory panel of experienced industrialists, consisting of Sir Francis Brake, Mr. A. G. E. Briggs, Mr. W. C. Puckey, Mr. S. W. Rawson, Sir Alan Saunders and Mr. E. W. Senior. The London offices of the Commission would be at the Ministry of Supply, Adelphi, and, on the Continent, offices were to be established in Paris, Brussels, Cologne and Milan. The question of representation in other countries was still under examination. Government contracts would be arranged on normal commercial lines and payment would be in local currency.

The Minister added that food and raw materials were not included in the field to be covered by the Commission. Neither were machine tools, since present arrangements through the trade were adequate, but the Commission would help if required. The kind of stores which would be purchased were finished and semi-finished goods, including textiles, leather goods, hardware, engineering and electrical components, which normally did not involve special tooling or substantial alterations in lay-out or line production. No raw materials would be provided from Britain to fulfil contracts.

An Industrial Exhibition

LAST Tuesday, May 8th, there was opened at Vickers House, Broadway, Westminster, by Vickers, Ltd., an interesting exhibition of its products and those of its associated companies. This exhibition covers a floor area of 6500 square feet and has been staged during the period of the Festival of Britain to give overseas visitors an impression of the present-day activities of the Vickers group of companies. It will be open to the public from 10 a.m. to 5 p.m. each week-day except Saturdays and Bank Holidays until September 28th. It was opened by Lieut.-General Sir Ronald Weeks, chairman of Vickers, Ltd., in the presence of a number of invited guests. The exhibition consists largely of panels carrying photographs, drawings, &c., illustrative of Vickers products, including ships, dock gates, caissons, &c., cement works plant, presses, railway rolling stock, printing machinery, turbines, microscopes, pumps, aircraft, tractors, mine-winders, &c. Amongst actual exhibits we noted a toilet soap plodder, a Pyramid hardness tester, a Keenok paint mill, a book-stitcher, microscopes by Cooke Troughton and Sims, Ltd., Powers-Samas card-punching and sentry machines, Ioco plastic gearwheels, and V.S.G. variable delivery pumps and meters; and there are models of a coach of the Royal Train in which the Royal Family toured South Africa in 1947 and of the P. and O. liner "Strathmore." Brewery and associated plant is represented by photographs, &c., of the products of G. J. Worsam and Son, Ltd., and Robert Boby, Ltd. The interest taken by the group in the training of craftsmen is shown by panels dealing with the training of apprentices. The whole exhibition is designed to give an impression, in little space, of the very wide range of products made by Vickers, Ltd., and the Vickers group of companies. Only one side of their activities is not well represented. It is the making of armaments, a subject not suited to the purposes of the exhibition, nor, in present circumstances, easy to illustrate.

SUMMER SCHOOL ON THE THEORY OF DIELECTRICS.—A summer school on the theory of dielectrics will be held at the University of Liverpool from July 19th to 21st. Lectures will be given by Professor H. Fröhlich, Dr. B. Szigeti and other members of the Department. The course is organised in co-operation with the Institute of Physics and the British Electrical and Allied Industries Research Association. It is intended mainly for research workers in Government and industrial research laboratories. The lectures will deal with dielectric constant and loss—general theory and applications; connections between structure and dielectric properties; atomic mechanisms of polarisation; phase transitions; electronic processes in dielectrics. The summer school will be followed by a conference on dielectrics from July 23rd to 25th. The speakers include Dr. L. Hartshorn, Professor H. Fröhlich, Professor J. G. Kirkwood, Professor J. C. Slater, Dr. M. Magat, Professor C. P. Smyth, and Dr. S. Whitehead. Particulars of both summer school and conference may be obtained from Dr. Szigeti, Department of Physics, the University, Liverpool, 7; or from the deputy secretary of the Institute of Physics, 47, Belgrave Square, London, S.W.1.

Structural Engineering at the South Bank Exhibition

No. II—(*Continued from page 587, May 4th*)

THE Skylon is by now a well-known addition to the various towers and spires of London's horizon, and its outline is probably familiar to many of our readers. It may be recalled that the Skylon was the conception of Messrs. Powell and Moya, the architects who won the competition for a "vertical feature" for the South Bank Exhibition which was held in 1949. It consists of a steel-framed tapered cylinder, 250ft in length and 13ft in diameter at its centre, suspended 40ft above ground level by a system of cables and struts, as shown in the accompanying illustration. There are three inclined struts placed at equal intervals round the Skylon, each 70ft long. The tower shown in the centre, underneath the Skylon, was for erection only. Three steel cables are anchored behind each strut, and pass to the sheave block at its top; one of them continues in a straight line to a point of anchorage about half way up the Skylon, and the second and third pass through the spider at the base of the Skylon, and then over the second and third struts respectively, to the anchorages behind them. The object of this arrangement is to make the Skylon completely suspended and, at night, when the cables and struts remain in darkness whilst the Skylon itself is illuminated, it will give the illusion that it is completely unsupported.

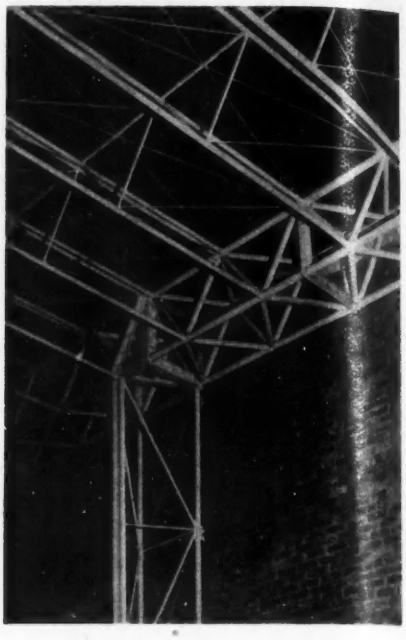
The weight of the Skylon is about 28 tons. In accordance with information received from the Air Ministry, the maximum wind velocity to be expected at a height of 300ft was taken as 80 m.p.h., and wind tunnel tests on a model showed that an impact factor of 1·6 should be allowed for. These figures were taken as the basis of the design, but with normal construction, in addition to these forces, dynamic forces would have been set up by the oscillations of the feature itself. With a completely suspended object like the feature such dynamic forces would be very considerable, actually in excess of those produced by the dead load and wind, causing very large movement.

It was therefore decided to prestress the cables, so as to increase the rigidity of the completed structure. The effect of the wind would be to slacken the cable on the leeward side. Therefore, by giving the cables an initial tension, so that a residual tension would still be acting under the slackest conditions, an increased rigidity was obtained, and only small moments resulted. A further advantage of this prestressing was that subsidiary side cables to brace the three struts were not required, and the principal cables only, as described in the preceding paragraph, were sufficient.

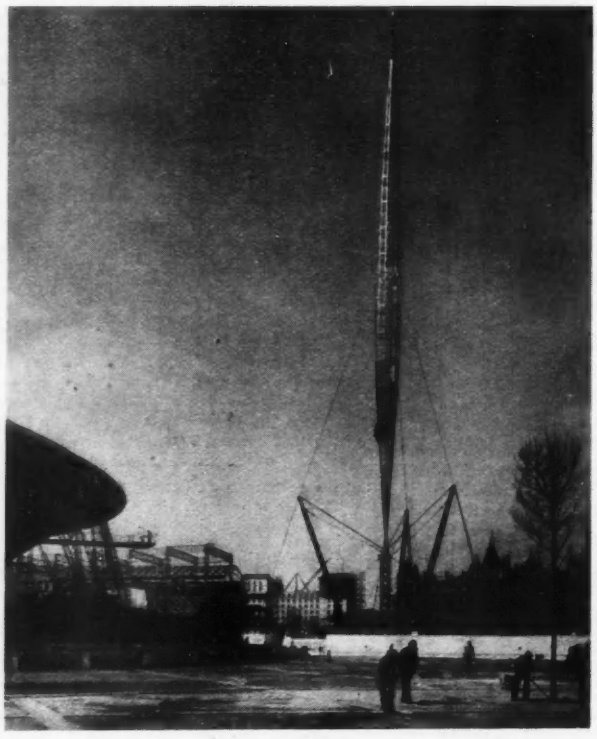
The method of applying the prestress is shown in the accompanying diagram. Each strut is pinned to a lever, which is itself pinned at one end. A hydraulic jack was placed under the other end. By pumping up the jack, the strut was forced upwards, thus inducing tension in the cables. The amount of prestress can, of course, be simply regulated by the jack. The force induced in each of the three cables at each strut was about 57 tons. The corresponding compression in the strut was about 181 tons, and the downward force at the bottom of the Skylon about 170 tons. It was calculated that under the worst design conditions a tension of 54 tons would be added to the windward cables and subtracted from the leeward, so that the tension would vary between 108 and 3 tons.

The spider at the base of the Skylon is the most crucial part of the structure. It is of welded steel construction and is also shown in the accompanying diagram, together with the sheave block at the top of the struts.

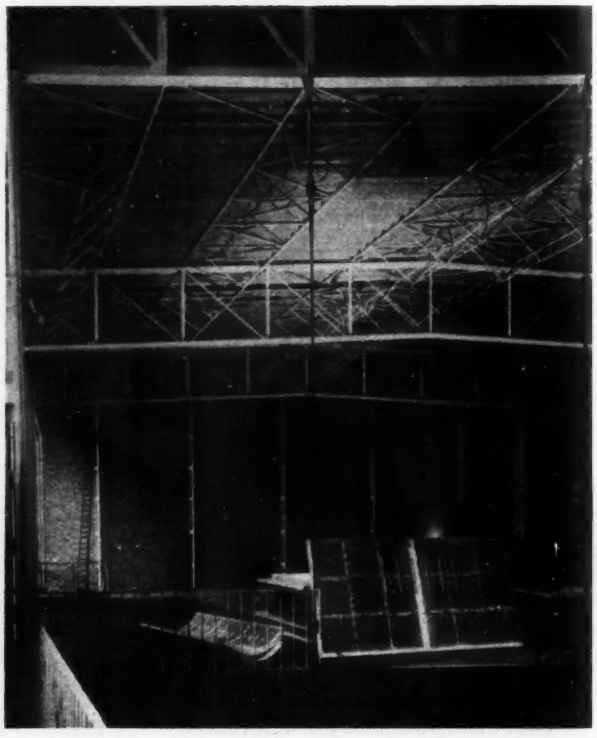
The Skylon itself consists of a welded steel frame covered with aluminium sheeting. It was built up from rectangular welded frames 12ft long, which formed a series of twelve-sided rings all with their own plan bracing,



STEELWORK DETAIL OF POWER AND PRODUCTION PAVILION

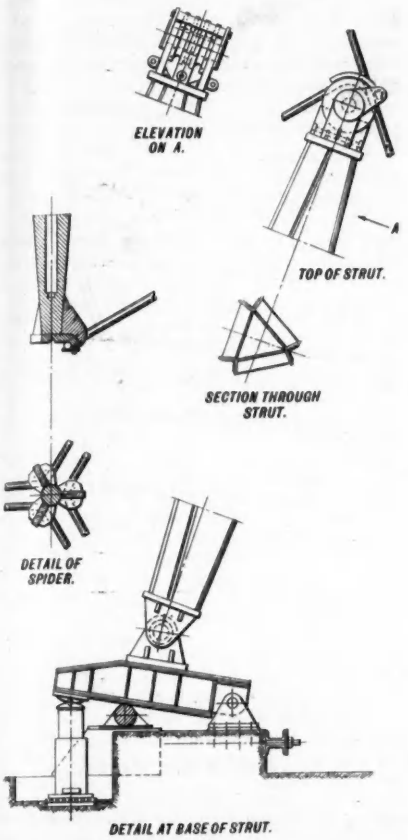


THE SKYLON NEARING COMPLETION



STEELWORK OF POWER AND PRODUCTION PAVILION

when bolted together. Considerable care was taken to ensure a satisfactory solution of all the welding problems, and various trial assemblies were carried out at the makers' works. The Skylon was erected with the aid of a steelwork tower 4ft square and 46ft high at its base. A light crane was mounted on the top of each last completed section, and the elements of the next section were hoisted into place. The reinforced concrete footings taking the loads from the supporting struts consist in plan of a framework, with nodal points under the struts, and with members connecting each of these points with the corresponding cable anchorage.



DETAILS OF STRUT AND SPIDER

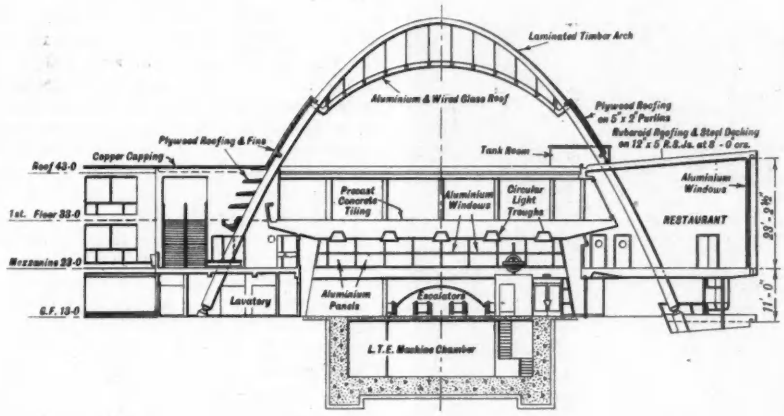
The structural engineering consultant responsible for the Skylon was Mr. F. Samuely, Messrs. Freeman, Fox and Partners being responsible for the foundations. The main contractors were British Insulated Callender's Construction Company, Ltd., the fabrication being carried out by Painter Brothers, Ltd.

Welded Steel Construction

Two of the exhibition buildings for which Mr. F. Samuely was also the consulting engineer are the Power and Production Pavilion (architects G. Grenfell Baines and H. J. Reifenberg), and the Transport Building (architects, Messrs. Arcon). Mr. Samuely's chief assistant for both the Skylon and the Power and Production Building was Mr. F. D. Green, and in connection with the Transport Building he worked in collaboration with Mr. H. Gottfeldt.

The Power and Production Pavilion is constructed of welded tubular steel. It is about 300ft by 100ft in plan and 50ft high, and the cladding consists of corrugated asbestos, brick panels and glass. The accompanying illustrations show typical examples of the framework of the building, from which it will be seen that the steel members consist of tubes or rods, welded together to form a system of space frames. This method of construction was considered particularly appropriate in this case for two reasons. The steelwork is not so prominent as with the more conventional use of trusses and purlins and has a much cleaner appearance, particularly at the connections. It therefore has a considerable appeal to the architect. Added to that, it is economical in cost, an important point on the South Bank site, where the budget available for the various buildings was strictly limited. In the case of the Power and Production Pavilion the steelwork accounted for only about 25 per cent of the cost of the building. The building was illustrated on Plate 4 of our issue last week, where it may be seen behind the Royal Pavilion.

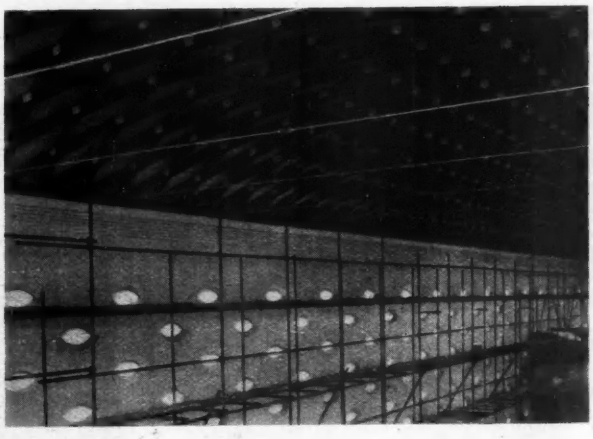
The Transport Building is one of the larger exhibition buildings, its pleasing appearance, with the large, sloping, glass front and sliding doors being shown in Plate 3 of our issue last week. The steelwork is more substantial than in the case of the Power and Production Pavilion, since it was required to hang aeroplanes from the roof at various points. The roof is built on a principle which is analogous to the shell roof used in reinforced concrete construction. The roof, however, remains the usual multiple pitched shape, associated with roof trusses and purlins, but no columns are required under the valleys. In this case the "trusses" run longitudinally, from end to end, and each one is inclined so that it lies actually in the plane of the slope of the roof. The "trusses" are rigidly connected across the peaks and valleys at various points, so that a structural system with similar properties to the shell roof is obtained.



THE WATERLOO GATE

We illustrate below one of the staircases in the Transport Building. It has a central cast-in-situ runner, to which precast treads are bolted. This design competes economically with the more usual forms of construction and gives an appearance of archi-

CONCRETE STAIRS IN THE TRANSPORT PAVILION

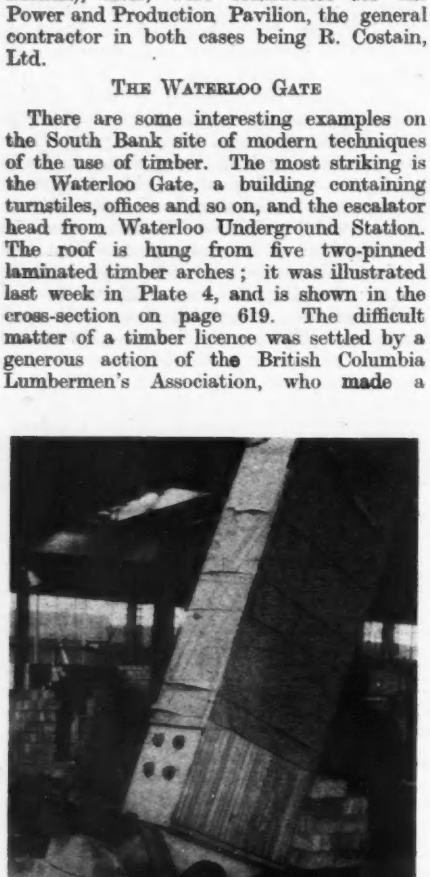


ROOF OF LION AND UNICORN PAVILION

tectural novelty. The steelwork contractors for the Transport Building were the Appleby Frodingham Company; Scaffolding (Great Britain), Ltd., were contractors for the Power and Production Pavilion, the general contractor in both cases being R. Costain, Ltd.

The Waterloo Gate

There are some interesting examples on the South Bank site of modern techniques of the use of timber. The most striking is the Waterloo Gate, a building containing turnstiles, offices and so on, and the escalator head from Waterloo Underground Station. The roof is hung from five two-pinned laminated timber arches; it was illustrated last week in Plate 4, and is shown in the cross-section on page 619. The difficult matter of a timber licence was settled by a generous action of the British Columbia Lumbermen's Association, who made a



Detail of Pin Joint of Arch

gift of the fourteen standards of Douglas fir, which were required. Apart from the arches and suspended roof, the building is steel-framed or of reinforced concrete.

The arches are parabolic and are fastened by 2¼in diameter steel pins at the springing. The illustration above clearly shows the detail at the springing and the laminations of the arch itself. The arches were delivered to the site in half-lengths and were erected with a crane, a rigid joint being made at the crown. Each half-arch measured 95ft in length, was 20in by 13¼in in cross-section, and weighed 2·2 tons. The span of the arches is about 100ft and the rise about 60ft. The bracing panels, which form the roof at each side of the suspended glass portion and give longitudinal rigidity to the five arches, consist of panels of wood framing faced with Douglas fir and Gaboon plywood, each one being about 24ft long by 18ft wide and 6in thick, and weighing about 15 cwt. In manufacturing the arches, planks 1in thick were kiln dried to a moisture content of about 10 per cent and then glued and moulded in a jig, which held them under pressure for forty-eight hours.

The architects of the Waterloo Gate were Sir John Burnet, Tait and Partners, and the consulting engineers Freeman, Fox and Partners. The timber design was carried out by the Timber Development Association, which was also responsible for the design of the two next examples mentioned below.

Our second illustration, on Plate 4 in last week's issue, showed, in the foreground, the Royal Pavilion. This building is heptagonal in plan and consists of seven laminated half-arches, very similar to those described above but much smaller in size. They are pinned at their bottom ends and abut on a central ring, also of laminated timber, at their top. This framework carries a roof of stressed-skin plywood panels. The architects were the Architects Co-operative Partnership.

The Royal Festival Hall provides the third noteworthy example of the use of timber. Apart from the normal uses, such as for flooring and panelling, an unusual problem was presented in the design of the orchestra canopy, for which timber was considered to be the most suitable material. The size of the canopy is about 80ft by 40ft in plan. It consists of six plywood box-girders, each suspended from the roof at three points by steel rods; a number of transverse plywood beams run between the box-girders and the three curved panels forming the canopy itself, are suspended from these beams by light steel hangers. The panels are of stressed skin construction with a veneer of sycamore on their lower surfaces.

Another building in which timber has been employed is the Lion and Unicorn Pavilion (architects, R. Y. Goodden and R. D. Russell). This building has a "lamella" roof, a system which embodies the geodetic principle of construction, as may be observed from the accompanying illustration. The roof covers an area of 45ft by 192ft, the "lamella" framework being of oak. There is a similar "roof" in the Sea and Ships Building, which is shown to the left of the Skylon in our first illustration. In this case, however, the building consists of a number of portal frames of laced angle steelwork, enclosing a space 50ft wide, 40ft high and 300ft long, from which various "roof" structures, including a dome, are suspended. The architect of this building was Mr. Basil Spence, and the consulting engineers were Freeman, Fox and Partners.

The Use of Reinforced Concrete

The Sea and Ships Building also includes an example of light reinforced concrete slab construction. There is a 4in reinforced concrete slab, 84ft by 18ft in area, which is supported on five steel columns, spaced at 18ft centres down the centre line of the slab, each with a steel cross beam consisting of a 12in by 4in channel section running transversely above it.

The Minerals of the Island Building is of reinforced concrete construction throughout. It consists of a turf-covered base 80ft square, with a tetrahedron 70ft high above it. The tetrahedron is of thin-walled reinforced concrete design, and its surface has been made to look like coal. It was illustrated in Plate 4. There is also a reinforced concrete entrance

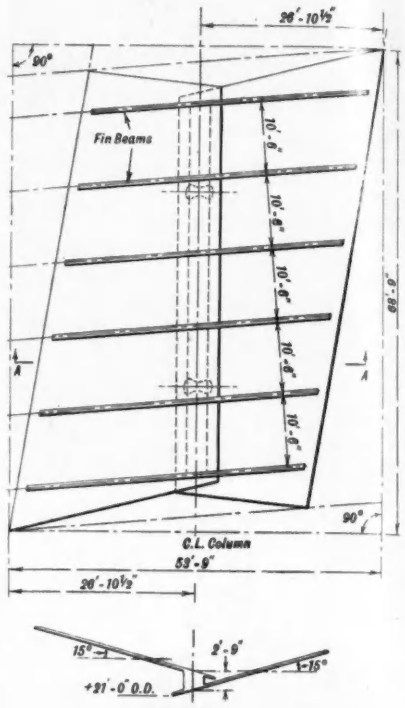


Diagram of R.C. Canopy

canopy in this part of the site, which gives an idea of the lightness which is possible with reinforced concrete. The dimensions of the canopy are shown in the diagram below. The uneven shape of each half meant that torsional stresses had to be allowed for along the centre line, where spiral reinforcement was provided.

The two structures mentioned in the previous paragraph were designed by the Architects Co-operative Partnership, and Messrs. Ove Arup and Partners. The same two firms were responsible for the suspended offices, illustrated in Plate 4 in front of the Minerals of the Island Pavilion. As may be observed, a series of "A" frames, with a longitudinal steel member connected across

Aluminium Shell Roof of Restaurant

their tops, are positioned to form a circular arc, and the offices are hung by wire ropes from the "A" frames. A corridor connecting the offices forms structurally a horizontal arch which gives lateral stability to the offices. There is also a decorative steel screen, 60ft high, in this area which is built up of a triangulated system of welded tubular steelwork, which supports squares of canvas arranged in a depth of 14ft, to give a three-dimensional effect when viewed from the exhibition grounds.

Lastly, it should be mentioned that in the downstream section of the site, there is a restaurant on the river bank which makes use of an aluminium structural panel for the roof* (architects, Messrs. Fry, Drew and Partners). The restaurant is illustrated herewith, and it may be seen that it has a shell roof, which is of 27ft span. This roof is built up of curved panels, each 8ft by 4ft in size, and riveted together. Each panel consists of a 2in layer of baked cork slab glued between two sheets of 20-gauge aluminium alloy.

A Steel Strip Feeding Machine

A NEW machine recently designed and constructed by Caledonian Works, Princes End, Tipton, for the continuous drawing of high-carbon and alloy steel strip through process furnaces is shown in the illustrations on this page. It is designed to handle strip up to 16in wide, and in the case of hardened and tempered carbon steel up to 0·08in thick.

The machine consists essentially of two large drums over which the material is wrapped and tightened by two rubber-covered pinch rolls working in opposition to a suitable brake situated at the input end of the furnaces. By adjusting the tension, sufficient friction is obtained between the strip and the drum surface for the latter to pull the strip without slip. A 10 h.p. motor drives the machine through vee belts coupled to the input side of a variable-speed P.I.V. gearbox. The output shaft of the gearbox is coupled to a worm reduction gear and a spur gear reduction train terminating in a pinion driving the forward drum. The provision of the gearbox enables the speed of the drums to be varied from 3·1ft to 18·8ft per minute. By changing the gearbox input pulley this speed range can be altered to suit different materials.

The pinch rolls are driven by a train of gears meshing with the rear drum via an adjustable, oil-immersed slipping clutch. The ratio of this gearing is such that, when the rolls are removed from the machine for resurfacing, their speed can be adjusted to suit the reduced diameter.

* See THE ENGINEER, March 16, 1951, page 359.

The upper pinch roll is mounted in fixed bearings in the frame of the machine, whilst the lower roll is mounted on a yoke member which is pivoted about its meshing gear centre. This yoke is elevated to its working position by two direct-acting cams which are partially rotated by a link and elevating screw mechanism. This form of construction dispenses with the need for variable-centre gears and universal joints, and ensures that the two rolls are driven at equal speed at all settings.

The take-up spool is driven through a friction clutch, and it is provided with a positive claw clutch which, in conjunction with a non-return latch stop, enables the spool to be disconnected from the driving portion of the machine to facilitate removal of the coils of processed strip.

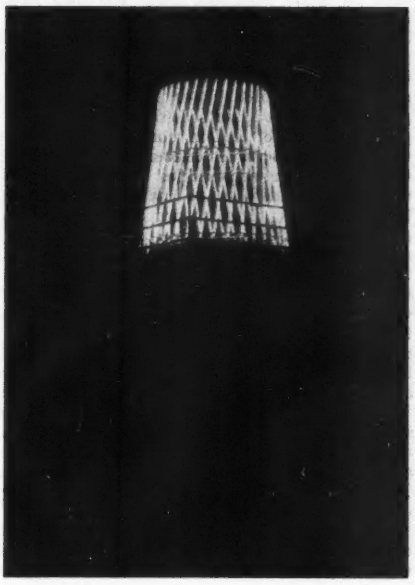
An overhead gantry above the take-up spool is provided with a trolley and pull lift hoist for handling the large spools of heavy material after they have been wound. The spool drum is mounted on a self-centralising taper with a key drive, and secured by means of a large nut and "C" washer to facilitate rapid removal.

All the moving shafts are mounted on adjustable Timken taper roller bearings, and the main frame of the machine is constructed from two heavy steel plates rigidly separated by stout spacer bars. The makers state that the machine has been designed and built for continuous operation twenty-four hours a day, seven days a week.

Identification Beacon at London Airport

NAVIGATIONAL aids at London Airport have been augmented by the installation of a new 7kW identification beacon, employing mercury-filled cold cathode fluorescent tubes. The beacon, which was supplied and designed by the General Electric Company, Ltd., to meet Ministry of Civil Aviation requirements, under the technical direction of the Chief Mechanical and Electrical Engineer's Department of the Air Ministry, gives a total light output from its thirty-six tubes of 180,000 lumens. It flashes the airport identification letters in Morse five times a minute, the colour produced by the fluorescent coating being green.

The cold cathode tubes were made specially for the beacon by Claude-General Neon Lights, Ltd. Each tube consists of a lighting tube enclosed in an outer jacket to provide maximum efficiency at low ambient temperatures. The lighting tubes operate at 300mA and are 30mm in diameter. Their individual light output of 5000 lumens compares with 2125 lumens from the standard 20mm diameter tube of the same lighting length (8ft 6in) but taking a current of 120mA. To supply the tubes there are nine transformers, each of which operates four tubes in series. The beacon structure is designed so that the connections between the transformers and the tubes, as well as those between the tubes themselves, are as short as possible. For this reason the transformers are mounted on a circular platform immediately below the ceiling of the beacon hut, and are arranged so that the output connection from each runs direct to a lead-through insulator immediately above it. The other end of the lead-through insulator is close to the group of four tubes it serves. A three-phase supply is fed to the beacon from an adjacent substation, where it

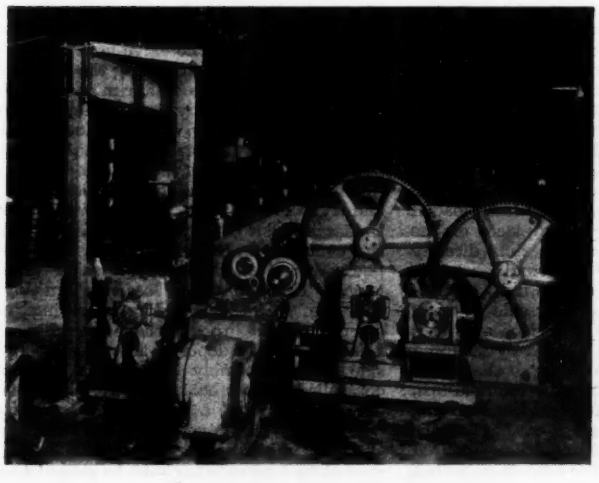


IDENTIFICATION BEACON AT LONDON AIRPORT

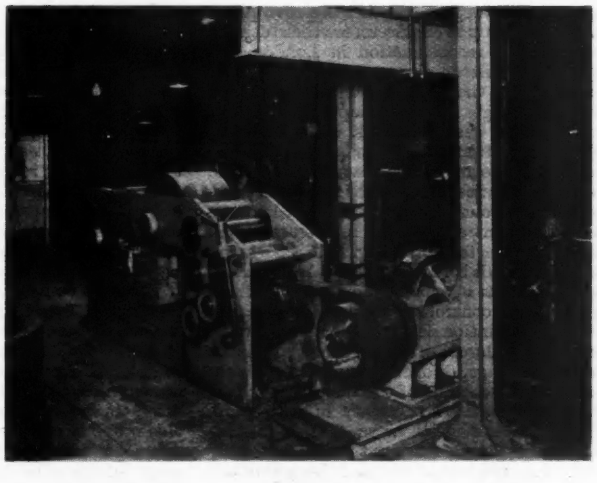
is switched by means of contactors remotely operated from the airport control tower. A triple-pole switch-fuse is mounted in the beacon hut. One phase of the supply is used to operate the 1/15 h.p. capacitor motor driving the cam, which causes the beacon to flash the Morse signals required. The same single-phase source energises the coil of the three-phase lighting contactor under the control of contacts operated by the cam. A 20A ironclad triple-pole and neutral fuseboard distributes the supply to the transformers.

A Correction Broach

A SPECIAL broach now being manufactured by B.S.A. Tools, Ltd., of Birmingham, is designed to correct distortion in components after case hardening. This correction broach was produced after a considerable amount of research and experimental work which was instigated by a leading motor-cycle firm. This firm had to remove from some thousands of



DRIVE SIDE OF MACHINE



CONTROL SIDE OF MACHINE AND TAKE-UP SPOOL

clutch hubs and dog clutches the distortion which had occurred in the splined bore during case hardening. In the manufacture of these units distortion had been a retarding factor in all attempts to speed production, as the components, however carefully heat-treated, always showed a certain amount of distortion, particularly on irregular shapes and multiple splines.

In its experiments the B.S.A. Company, when developing the correction broach bearing, kept in mind the fact that the two most important factors affecting the tool were that it would have to be produced at the lowest possible cost and that a Rockwell C hardness figure of 65–66 must be maintained to ensure a reasonable tool life. After preliminary work a push-type broach, suitable for use on a vertical press, was made, and in consideration of the very high stress values encountered the broach was kept as short as possible. The desired hardness was obtained and a final liquid nitriding treatment was given to impart a glass-hard surface. This hard surface gave the broach an exceedingly long life. The broach was designed to burnish the top diameter and the side faces of the splines. The distortion itself was rectified by pushing back the protrusion to the original level without removing any metal. This compressive action, it is stated, has no detrimental effect upon the material and there is no risk of the formation of cracks.

The broaches which are now available are suitable for use on components after all carbon and carbon/nitrogen case-hardening treatments, and they will correct distortions up to 0·005in. The recommended lubricant for the broaching operation is "Trefolex."

In the works of the motor-cycle firm concerned with the original inquiry, one broach was used to correct the entire batch of 2800 clutch hubs which had previously been tight on the sliding shaft. This original broach is still in use on the same operation. Similar broaches have also been used by other engineering firms experiencing distortion problems, who are stated to have found this quick and easy method of correcting thermal distortion to be completely satisfactory.

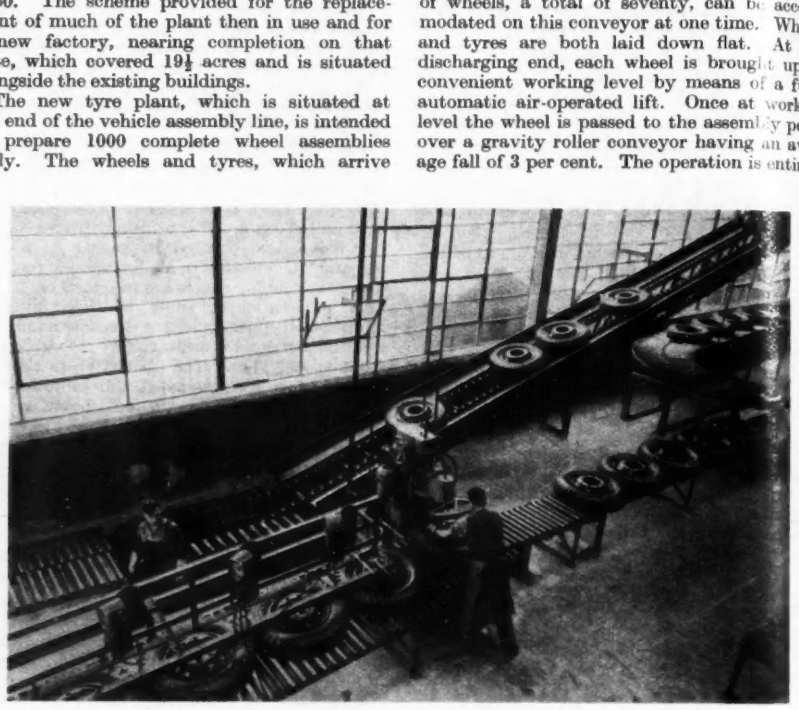
Town and Country Planning

A PROGRESS report, covering eight years of town and country planning up to the end of January, 1951, has been presented to Parliament by the Minister of Local Government and Planning and was published as a White Paper (H.M. Stationery Office, price 5s.) at the end of last week. The first part of the report sets out the accumulation of problems which led to the establishment of a Ministry of Town and Country Planning and also refers to the progress which has been made. The need for comprehensive planning control, the report claims, is now widely accepted, although the provisions of the Act relating to development control have been criticised, mainly on the score that development control under the Act is too detailed and that the procedure of getting planning permission is too slow and cumbersome. Chapters of the report, which will prove particularly interesting to engineers, are those dealing with plans for reconstruction in London, the progress of work on the new towns, and the plans made by the Ministry for the control of mineral working. Another chapter gives some account of the research work undertaken by the Ministry. It states that the planning technicians—who form the largest group of the Ministry's technical staff—advise on all questions of the lay-out and arrangement of land use and development and on the architectural and engineering aspects of planning. The report says that an attempt is being made to establish certain broad standards of general application, which can be used in controlling the lay-out of buildings. The intention is, so far as possible, to prescribe standards of daylighting, of space between buildings, of open spaces and so forth. In addition, a schedule of the minimum widths of streets considered necessary in residential, business and industrial areas, has been prepared in conjunction with the Ministries of Health and Transport and will be published shortly.

New Plant at the Vauxhall Works

A NEW storage and handling system for the wheels and tyres of commercial vehicles has recently been completed at Vauxhall Motors, Ltd., Luton. This plant is part of a three-year extension and modernisation scheme estimated to cost £10 million, about which a general account was given in THE ENGINEER, of April 21, 1950. The scheme provided for the replacement of much of the plant then in use and for a new factory, nearing completion on that date, which covered 19¼ acres and is situated alongside the existing buildings.

The new tyre plant, which is situated at the end of the vehicle assembly line, is intended to prepare 1000 complete wheel assemblies daily. The wheels and tyres, which arrive by road separately at the storage section, are issued, to schedule, to the wheel assembly section, from where they emerge as complete units, with tyres inflated, and are conveyed to the vehicle assembly line.



THE ADAPTED PFAUTER GEAR HOBBER AND CONVEYORS

RECEPTION AND STORAGE

The tyres, arriving by road, are unloaded by hand and packed in specially designed post pallets, which are transferred to the storage area by fork-lift truck and stacked according to size and make of tyre, there being thirteen different kinds of tyres. The pressed steel, ventilated-disc wheels, with split ring, are received with the ring ready assembled and are unloaded from the lorries and placed in pallets by a fork-lift truck, using one fork as a "pole" or "jib." The pallets are carried to the storage area by fork-lift truck, each pallet holding thirty-five wheels.

ISSUING SECTION

Approximately 11,500 square feet of floor space are set aside for stacking pallets in the storage area. A fork-lift truck carries unit loads from the stores to two power-driven conveyors, placed one above the other, one of which handles wheels, the other tyres. An elevated platform, 64ft long, 20ft wide and 4ft 9in high, is built around these conveyors. The tyre conveyor runs along and through the centre of the platform, at the same height above the ground. The tyres are hand-loaded on to this conveyor from pallets placed on the platform. The wheel conveyor runs directly beneath the tyre conveyor at ground level.

The tyre conveyor is a double unit, consisting of two 64ft lengths running side by side, separated by a cat-walk 1ft wide, and uses Renold chains linked by freely-mounted rollers. The rollers rotate freely so that there is no need to stop the conveyor for hold-ups, when it is carrying a full load. Flanking this double conveyor are cat-walks for the operator, who can load from either side. A short length of gravity roller conveyor, with a fall of approximately 4½ per cent, carries tyres from the discharging end of the power-driven conveyor to the assembly point.

The wheel conveyor is similar in construction, but is single-track and runs at ground level directly beneath the tyre conveyor. It is 28ft longer than the tyre conveyor, the extra length constituting the loading section. Ten sets of wheels, a total of seventy, can be accommodated on this conveyor at one time. Wheels and tyres are both laid down flat. At the discharging end, each wheel is brought up to convenient working level by means of a fully automatic air-operated lift. Once at working level the wheel is passed to the assembly point over a gravity roller conveyor having an average fall of 3 per cent. The operation is entirely automatic and one operator only is required to load both wheel and tyre conveyors.

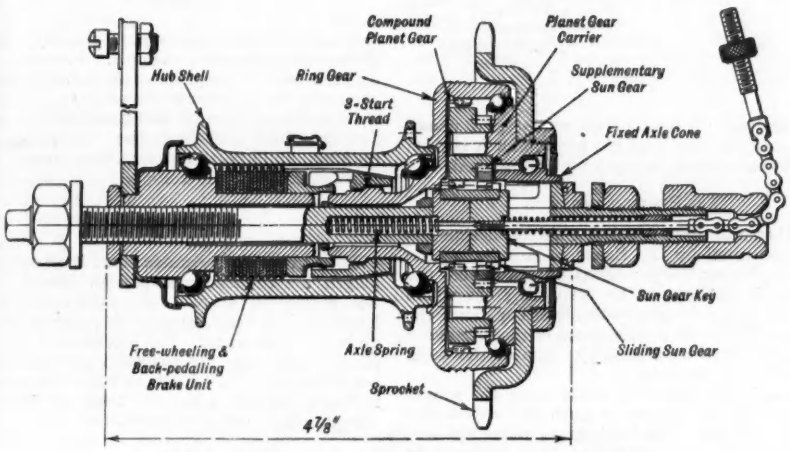
ASSEMBLY AND DISPATCH

The assembly station consists of a length of roller conveyor 50ft long. It incorporates flanged edges, so that the lips of the wheel-rims fit under the edges of the flange and hold the wheel firmly whilst assembly operations take place. These operations include removal of the split rim on the wheel, placing the tyre and inner-tube assembly on the wheel, replacing the split rim on the wheel-and-tyre assembly, and inflating tyres to the correct pressure.

Where the tyres and wheels meet, the operator controls the flow of tyres by means of a special arrangement incorporated in the tyre conveyor. A foot pedal actuates a set of three plungers; one is raised and two lowered, thus holding up the flow of tyres, leaving one to run free. This tyre is carried forward within the reach of the operator by the sliding part of the conveyor. The operator positions the valve of the tyre through the valve-hole in the wheel and retracts the slide, allowing the tyre to drop over the wheel. The split rim is replaced on the wheel assembly by a machine, which was specially converted by Vauxhall Motors Ltd., for the purpose. It was formerly a Pfauter gear hobber. Now it performs the rim-clinching operation without the need for the use of hammer and tyre lever. The same operator inflates the tyres and a gravity roller conveyor delivers the complete wheel assembly to an overhead power-driven chain conveyor which is 280ft long. This conveyor ascends quickly to the roof of the building, carrying wheel assemblies to the vehicle-assembly line. It automatically deposits the wheels on either side of the assembly line via an electrically-controlled counter-balanced gate, which delivers the wheels down a short chute. Counters, actuated by the movement of the wheels, open the gate in the proper sequence, allowing the correct number of wheels to be passed to each chute.

A Combined Three-Speed Gear and Back-Pedalling Brake

UP to the present all three-speed gear-changers used in the manufacture of American bicycles have been imported, largely from the United Kingdom. As with British practice, most of these units were only gears and not combined with free-wheeling and back-pedalling brakes, which are extremely popular in the U.S. Recently the first American three-speed gear and back-pedalling coaster brake, combined within a standard rear-wheel hub unit, was introduced under the trade name "Triplspeed," by the New Departure Division of the General Motors Corporation, of Bristol, Connecticut. This compact device embodies preselection of gears, synchro-meshing of gears without clashing and, through a control lever situated adjacent to the handlebar grip, gear changing may be performed without removal of the cyclist's hand from the grip. With the new unit three gear changes can be obtained: low gear in direct drive and two successive overdrives. The gear changes are the same as those used by Sturmey-Archer, Hercules and other manufacturers—25 per cent reduction from normal gear and 33⅓ per cent increase from normal gear. This overall range of gears can be varied by changing the sprocket.



THREE-SPEED GEAR AND BACK-PEDALLING BRAKE

The gear, which is illustrated in the accompanying drawing, consists essentially of a sprocket driven by the bicycle chain, a planet gear carrier, to which the sprocket is attached, four compound planet gears rotating on the planet gear carrier studs, a ring gear, with which the teeth of the larger planet gear are constantly in mesh, a sliding sun gear with a large supplementary sun gear and an axle to which an axle cone is permanently fixed. The ring gear has a three-start thread extension, which normally drives the hub shell and, on back-pedalling, serves to apply the brake. In low gear the sun rotates freely on the axle sleeve. One set of sun gear teeth mesh with the large planet and the other set of sun gear teeth are in engagement with the supplementary sun gear, the outer teeth of which mesh with the smaller planet gear. Since it is impossible for the compound planet gear to revolve about sun gears of unequal diameters, the mechanism is locked and is driven as a unit about the axle, resulting in a direct drive. When the sliding sun gear is moved outward, it is disengaged from the supplementary sun gear and immediately engages in the internal teeth of the fixed axle cone. Thus the sun gear becomes stationary, allowing the large planet gear to revolve about the sun gear and causing the ring gear to revolve. This results in the first overdrive or normal gear. As the sliding sun gear is moved further outward and deeper into the fixed axle cone, the corresponding teeth of the sliding sun gear engage with the internal teeth of the supplementary sun gear, allowing the small planet gear to revolve about the now larger sun gear. The large planet gear, being integral with the small planet gear, drives the ring gear. This results in the second overdrive or high gear. The outward movement of the sliding sun gear is effected by the control lever pulling on the control cable. When the cable tension is released by the lever, the sliding gear is allowed to move inwards, resulting in successive gear changes to normal and low. The free-wheeling and back-pedalling brake unit functions in conjunction with any one of the three gears.

As a synchro-mesh transmission the gears cannot clash during gear changes because the sliding sun gear teeth always leave one set of mating gears before entering into another. The gears are so designed that the moving gear, regardless of speed, always finds its mating gear without lost motion and without clashing; hence changing can be performed at any time. Preselection of any of the three gears may be accomplished, while pedalling, by shifting the control lever to the desired gear in advance. When the rider wishes to change gear, he relieves his pedalling pressure momentarily, whereupon the gear shift occurs rapidly and automatically. When pedalling is resumed the bicycle is in the gear which had been preselected. Preselection is effected within the gear in the following manner. The position of the sliding sun gear is directed and predetermined by the movement of two separable keys, which are situated on either end of the sun gear and are backed by two springs within the axle. With the sliding sun gear under torque due to pedalling, the gear changing lever is moved to the desired gear position, which results in the sun gear key being displaced along the horizontal axis accordingly. When the torque is removed from the sun gear momentarily by the stopping of the pedalling movement the axle spring automatically moves the sliding gear to the predetermined position. Upon resumption of pedalling, the sliding sun gear has assumed its appropriate position and the unit is in the desired gear.

Another characteristic of the gear is the location of the gear-changing lever assembly near the handlebar grips. Thus, changing of gears is performed without the necessity of removing the hand from the grip. Changing from low to normal to high is done by pulling up on the lever with the fingers. Changing from high to normal to low is effected by pushing down on the release lever with the thumb.

Continental Engineering News

(From our Continental Correspondent)

The Straits of Messina Bridge

The Association of Italian Steel Builders recently asked the well-known American bridge designer, Mr. D. B. Steinman to prepare a design of a suspension bridge across the Straits of Messina, between Italy and Sicily. The width at the point considered amounts to about 10,000ft and the design has two side spans, each 2394ft long and a central span 5051ft long (exceeding by 800ft the central span of the Golden Gate Bridge at San Francisco, U.S.A.). The proposed bridge presents several points of technical interest; an innovation is the shape and arrangement of the stiffening girders, whose role in such a long span structure is of major importance. These girders will have a depth corresponding to the bending moments, with a maximum at midspan for the side spans, and at the quarter points for the central span extending up to the suspension cable at the points of maximum depth.

It is estimated that the construction of the bridge will require about 74,500 tons of steel for the towers and stiffening girders; 46,500 tons of steel for the cables, and 550,000 cubic yards of concrete for piers and abutments. The cost of the bridge would be about 42,000 million lire (about £25 million).

The Vila Franca Bridge (Portugal)

An important highway bridge is at present being built over the Tagus at Vila Franca de Xira, some 15½ miles from Lisbon. It consists of five steel spans, each 336ft long, and its total length, including approach spans, amounts to 4014ft, of which 1699ft constitutes the river crossing. The decking accommodates a 29½ft roadway and two footpaths, each 5ft wide.

The main spans consist of bow string arch girders, spaced at 34·6ft centres. The arch ribs and stiffening girders are of riveted high-tensile steel, but other elements of the steel superstructure are of mild steel. About 3000 tons of steel will be required altogether. Piers and approach spans are of reinforced concrete construction.

The bridge is being built for the Portuguese National Road Board by the Sociedade de Empreitadas e Trabalhos Hidraulicos (S.E.T.H.). This firm is responsible for the substructure and the approach viaducts, in collaboration with two Danish companies which specialise in foundation work. The contract for the manufacture and the erection of the steelwork was let to Dorman Long and Co., Ltd., of Middlesbrough. The erection of the steel superstructure (by means of a service bridge) is at present making good progress, and it is expected that the bridge will be completed before the end of this year.

Works at Harlingen, Holland

Important hydraulic works are at present being carried out near Harlingen (N.E. Holland), including the improvement of 100 miles of old canals, and the excavation of new canals, designed for 1000-ton barges. The construction of various highways, bridges and locks is also involved. Work on the scheme was started in 1939, but was delayed during the war; it is now substantially completed.

Among the various structures of the scheme the breakwater is of rather original conception. According to Mr. E. Kuiper, Executive Engineer of the State Department of Hydraulic Works, the general method of construction was first to remove the soft sea bed by dredging, until a solid base was obtained. On this base an embankment was built up with sand, placed either by dumping or by pumping, and finally trimmed by excavators. A bituminous revetment was then laid to give resistance against erosion.

The locks which have been constructed measure respectively 23ft by 132ft by 10ft deep and 40ft by 460ft by 15ft deep. The volume of the earthworks in the complete scheme amounts to 1½ million cubic yards.

Designing a Warship*

By SIR CHARLES LILLICRAP

Introduction

What is required of the warship designer? First and foremost he is the one man who must keep the ship as a whole constantly before him, for the claims, often conflicting, of the engineer, the gunner, the electrician, the radar experts, &c., must all be duly considered to produce a well-balanced design. Secondly, the designer must be an engineer in the true sense of the word, for a ship is basically a structure subjected to a variety of forces and loads. Thirdly, he must possess foresight and imagination, for a ship may not be completed until several years after the design was originally conceived and, in the case of a warship, may not be used for its intended purpose for an even greater number of years. Thus a ship as originally designed must be years ahead of its time. He must, furthermore, be blessed with a sense of the artistic—one might almost say he must be a creative artist—for who could abide an ugly ship, whatever its purpose? And, finally, he must possess a strong sense of humour. Without it he is a lost soul and his life becomes a burden to himself and to everyone with whom he comes in contact.

Preliminary Preparations

The design of a warship begins, of course, with a requirement, which, in turn, is dependent on current Naval policy and financial resources. It is important to remember that the considerations leading to the need for a new ship are based almost always on requirements, say, five or even ten years hence. This in itself is a difficult enough problem, for policies, particularly those controlled by political considerations, have a nasty habit of taking sudden turns. A change in the political or international situation may have a profound effect on the programme of warship building extending over a period of many years, for the politician provides the money and without it there can be no ship or ships.

Staff Requirements

A new warship is ordered in much the same way as any other piece of equipment. The Board of Admiralty, from considerations of naval policy, decide that new warships are required either as replacements to existing units of the fleet, which can no longer be economically maintained in operational use, or for a strategic or tactical purpose, for which no warships then available will serve satisfactorily. The naval staff then draw up a list of essential requirements for the new design. This takes the form of a statement of the approximate displacement of the vessel, the armament which is desired to be carried, either guns or aircraft; armour protection required, if any; minimum speed; amount of radar to be carried and any other features, which the designer must incorporate. These constitute what are known as the staff requirements and in the early stages are necessarily tentative in order to give the designer an opportunity to produce a ship which will reasonably satisfy the Board of Admiralty.

Sketch Design

On receipt of his orders from the Board of Admiralty in the form of staff requirements, the naval constructor investigates the possibility of meeting these requirements in what is known as the sketch design. The sketch design is to some extent the first shot aimed at satisfying the staff requirements and, although no more than an outline arrangement, it is worked out in sufficient detail to indicate whether such a design is practicable or not. Life is too short to make a full investigation into the possibilities of all projected designs at this stage.

It not infrequently happens that the requirements as first formulated cannot be met *in toto* and a grand tussle then develops in which the conflicting claims of speed, guns versus armour, torpedoes versus underwater protection, aircraft, habitability, &c., are fully considered by the naval staff on one side and the naval constructor on the other.

In an endeavour to obtain the most satisfactory answer, a number of different sketch designs may be worked out. These are submitted to the Board of Admiralty, who decide which design should be pursued in detail.

Compromise

Eventually a compromise is effected. That every design is a compromise is a time-worn and trite saying, but it is, nevertheless, a true one, particularly in the case of warships where the conflicting claims are so many and so varied. It would be a comparatively simple task for the designer if no such compromise were necessary and it were possible to give each section of the naval staff everything they wished.

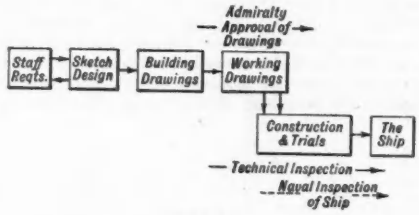


FIG. 1

Final Stages

When the most promising sketch design has been selected by the Board of Admiralty, the design is then fully worked out to enable the detailed drawings to be prepared from which the dockyard or shipbuilder can construct the ship. I intend to restrict most of the remainder of my lecture to describing some of the work involved at this stage.

Fig. 1 illustrates in block form the stages in the life of a warship from the conception of the design to the final stage, when the ship is accepted into service. I need hardly add that during the building of the ship we maintain a very thorough system of inspection to ensure that when completed the ship will satisfy the rigorous requirements of the Royal Navy, and it is thoroughly tested by a very exacting series of trials, which at the same time enable the designer to glean much useful data which can be used in later designs.

Process of Design

So far all that I have said is by way of introduction and I now propose to outline very briefly the various considerations involved in the process of design. A ship can be regarded primarily as a carrier of a given load. In the case of a warship this usually takes the form of a specified amount of armament—both main and secondary—or of a certain complement of aircraft, as required by the naval staff. Its weight can be evaluated and from this the total displacement of the ship can be estimated, the designer being guided as necessary by corresponding figures in previous similar designs.

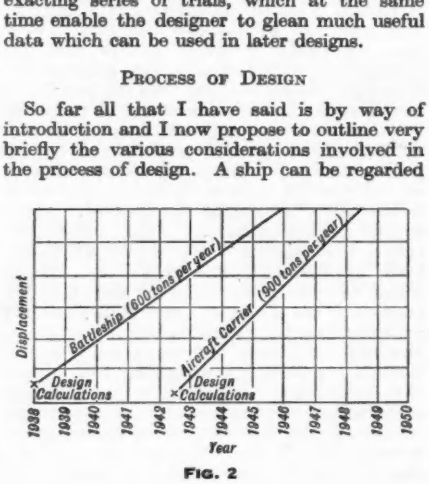


FIG. 2

Displacement

Displacement is the capital of the designer and this capital is limited either by Treaty obligations or other causes, such as docking and berthing, first cost and maintenance cost, or manning facilities. This capital is disposed over the several items comprising a ship as a whole, a few only of which are capable of much variation and the process of working out a design is always a tentative one because of the effect of one requirement on the provision to be made for others. If over-spending takes place on one item a corresponding amount must be taken from some other or others. Another factor to be taken into account is the inevitable increase of displacement, which takes place while the ship is being designed and built, as attempts are made to incorporate at all stages the most modern equipment and additional features arising from current developments.

It usually entails increasing the original complement, which, in turn, requires increased allowance for accommodation or reducing the standard initially envisaged. Reasonable allowance is made for this growth in the early design stages, but, despite this, the ship still grows with the passage of time (Fig. 2).

Dimensions

The principal dimensions, namely, for a given displacement, length, breadth and draught, are interdependent and are determined primarily by considerations of speed, stability, seaworthiness, strength and habitability. Other factors which influence the dimensions are docking and berthing facilities, canal and harbour restrictions, &c.

Length

For a given displacement there is an optimum length for economic propulsion governed by the maximum speed. For high speed great length is essential (except in planing forms), giving a fine form. The optimum length is usually too long for practical purposes since considerations of strength and transverse stability require a shorter length. Again, a compromise must be effected.

Stability and Beam

Associated with the great length required for speed is small beam. On the other hand, for stability purposes beam should be large. Adequate transverse stability is of prime importance in a warship which is required to withstand damage in action and its consequences, in addition to the normal seagoing risks. The longitudinal stability, i.e., for pitching, is inherently so great for a ship form that it requires no investigation.

Turning to transverse stability, i.e., against rolling, two features have to be considered at a very early stage in the design:

(1) Initial stability, or stability at small angles of roll.

(2) Range, that is angle to which the ship can heel before capsizing.

Both these features are affected by the position of the centre of gravity of the ship and by the form of the ship, and as the design advances very detailed calculations are made to ensure that their values are accurately assessed.

Initial Stability

Fig. 3 shows the cross section of a vessel heeled to an angle θ. The horizontal separation GZ, of the lines of action of the weight acting vertically downwards and the buoyancy acting vertically upwards is termed the righting arm or lever, and varies with θ in the manner shown. The righting moment is the displacement $\times GZ$ and the ship is stable if this moment acts in the direction returning the ship to the upright. The point M is termed the metacentre and for small angles of heel is a fixed point. Since $GZ = GM \sin \theta$, it will be seen that the stability of the ship, initially, depends on the distance GM—the metacentric height—and will be large if G is kept as low as possible in the ship or if M is high, obtainable by large beam. Action damage usually results in M falling so that the designer aims at keeping GM large. But for easy rolling a low metacentric height—that is, a gentle restoring

* Lecture. The Royal Institution, April 20, 1951.—Abstract.

action—is required, and, again, a compromise must be made.

Range and Freeboard

The range depends mainly on freeboard which is also affected by considerations of seaworthiness and habitability.

To illustrate these points I have taken two extreme cases of vessels with the same displacement; a Monitor with large beam and low freeboard has large initial stability in view of its liability to heavy damage, but small range, whereas the liner with smaller beam, but higher freeboard has small initial stability—for passenger comfort—and a very large range.

Draught

Draught is governed mainly by requirements of form and by considerations of canals, rivers, docks, &c. Sometimes special attention has to be given to draught if any particular scene of operations is contemplated, as, for example, in landing craft.

Form

The shape of the underwater form is of paramount importance, the length, beam and draught being fixed, for it largely governs the resistance to motion of the ship. The designer is guided in his choice of form by a curve of cross-sectional areas (Fig. 4); experience accumulated over many years enables him to select the best curve for a ship of given displacement and speed; a full curve is desirable for certain ships, e.g., destroyers, whereas finer curves are better for others, e.g., battleships. The curve of areas gives for each transverse section of the ship the area of the underwater portion. Thus at a number of sections along the ship the designer roughs in an approximate shape of the relevant area in the body plan. These are then tested for fairness by taking horizontal sections (by waterplanes, in the half breadth), and by vertical sections (bow and buttock lines in the sheer). Any unfairness in any of these curves is corrected, the modified transverse sections are checked for area, corrected, refaired, and so on. In this way, by the process of "fairing the ship," the underwater form is built up, having the requisite distribution of displacement. This form is recorded by three views showing the shapes of relevant sections in the body plan, sheer and half breadth. As a check on the suitability of the form, especially if alterations from the original have been made for any reason, a model of the form is thoroughly tested in a large tank at the Admiralty Experiment Works, Haslar, by towing from a self-propelled carriage. As a result of these tests modifications may be suggested to improve the performance of the form.

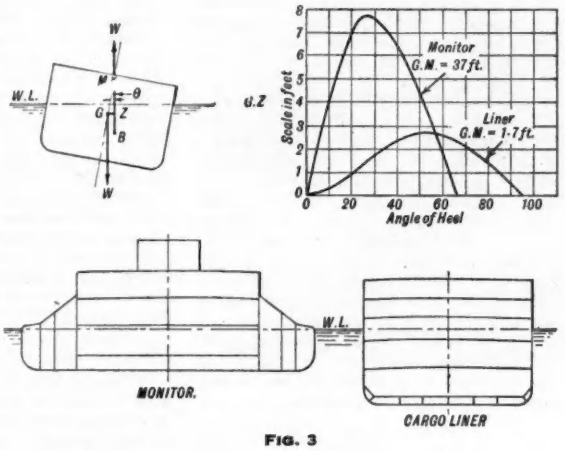


FIG. 3

Legend of Weights

The total displacement of the ship can be conveniently subdivided into six main weight groups:

(1) Weight of armament.
(2) Hull weight.
(3) Weight of machinery.
(4) Fuel weight.
(5) Weight of armour and protection.
(6) General equipment weights.

(1) Armament

This item comprises the "load" which the warship is required to carry, and includes armament of all descriptions—main, secondary, anti-aircraft, small arms and machine guns, and torpedoes and all the associated ammunition and stores. As already explained, this group weight largely determines the displacement of the ship; it constitutes about 15 per cent of the total displacement of a large warship.

Various factors determine the choice of the maximum calibre of the gun (in the past there have been certain limitations imposed by Treaty) and the grouping of the guns in turrets. More guns per turret leads to economy in weight, hence the quadruple turrets in the treaty-designed "King George V" battleships, but the greater the loss of fire power if a turret is put out of action. The practice for many years has been to mount the guns on the middle line, giving wider arcs of fire and leading to better protection to the magazines.

The future of the large calibre gun is doubtful and it is highly probable that in the course of time it will be replaced by large guided missiles.

The air attack on warships was considerably intensified during the last war and this inevitably brought the demand for very great increases in the number of anti-aircraft guns mounted, and with the passage of time, a continuous demand for increased calibre. Eventually the secondary armament carried for engaging light enemy craft was embodied in the A.A. guns, or vice-versa, by the introduction of the dual-purpose gun. The advent of radar led to better aircraft detection and gunnery control, though at the price of increased complexity and maintenance and, to-day, we have a system whereby the radar control will keep the gun "locked" to the target. The high speed of modern jet planes has led to requirements for these guns to be rapidly and continuously trained on the target and to have extremely high rates of fire, necessitating greater power supplies and increased spaces for ammunition, both of which eat into the precious capital of the designer—the displacement.

Aircraft

Another aspect of armament to which reference should be made here is the provision of aircraft. Now that aircraft have reached the size, weight and speed for modern performance they can no longer be carried generally in warships, as was done in the past, but only in aircraft carriers designed specially to carry and operate them. Some of the problems the designer is faced with are the heavier weights of aircraft and their weapons, requiring stronger and heavier flight decks; the high speed of jet aircraft, necessitating longer flight decks or more powerful catapults and stronger arresting gear, and so on.

Torpedoes and A.S. Weapons

Brief mention should be made here of the torpedo, which is essentially a weapon of the submarine, of the torpedo destroyer and of certain types of aircraft. Perhaps of more importance is the provision of anti-submarine weapons, such as depth charges. Both weapons are, however, becoming more complex in an attempt to increase their lethality.

(2) Hull Weight

The hull weight, i.e., weights of all plating, bulkheads, decks, superstructure, &c., absorbs a considerable portion of the displacement, 40 per cent or more of the total in large warships, and can be conveniently sub-divided into (*a*) structural hull weight and (*b*) weight of fittings.

(*a*) Structural

Since the hull group is the largest of those into which the displacement is divided, it is vitally important to design a robust hull with economy of weight. To this end as much as possible of the structure should be worked to contribute to general and local strength—this is where the skill of the designer can play such an important part. The steelmaker, too, can influence this item, as the better the quality of the material and the more dependable it is, the higher the stresses that can be accepted and/or thinner material used, with consequent weight saving. Here I may say that improvements in steel are still being made, although progress is slow. Welding in lieu of riveting offers possibilities for reducing structural weight but its use gives rise to many fresh problems.

Apart from local strength problems, which have to be fully investigated, the longitudinal strength of the hull must always be considered.

Strength

No undue risk may be taken but on the other hand the designer can only afford just sufficient weight for this item, otherwise other features of the design would be prejudiced—he cannot afford to be too safe. Our warships must be sufficiently strong to stand up to seas likely to be met in any part of the world, plus the possible effects of explosions from mines, torpedoes, bombs or depth charges.

The uneven distribution of weight and buoyancy, which is increased when the ship is among waves, produces longitudinal bending moments and shearing forces, as shown in Fig. 5. If the ship were a simple beam acted upon by known forces it would be a simple matter to determine the resulting stresses; but a ship is such a com-

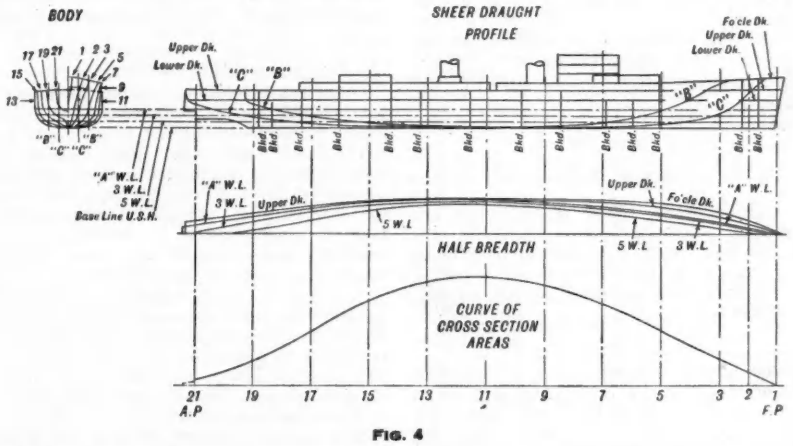


FIG. 4

plex structure and the conditions of loading so indefinite that the problem is not susceptible to simple calculation. Although nominal values for the stresses are invariably determined, using simplifying assumptions, the designer is thrown back on his experience and such experimental data as are available, comparison also being effected with previous designs found satisfactory in service. Even so, it sometimes happens that the designer cuts things a little fine to save weight, in which case he learns in the hard school of experience.

N.C.R.E.

We are fortunate in having an establishment whose work is largely devoted to experimental work in stress problems of all kinds, the Naval Construction Research Establishment. Among the more spectacular experiments carried out have been tests, often to destruction, of warships due for scrapping, subjected to the blast of bombs, shells and underwater explosions of various intensities. These tests have given us much valuable design data. Submarines have been tested by lowering in deep water to check calculations of their collapse depths.

(*b*) Fittings

This sub-group comprises all such items as ventilation, pumping, flooding, drainage and electrical fittings, furniture, &c., which are not directly necessary for structural purposes but which may well total 25 per cent of the hull weight group.

There is scope here for the use of light materials, such as aluminium and its alloys, and plastics of all description in order to reduce weight to a minimum. A lot of time and thought is spent in designing fittings for all purposes with this end in view. There is a limit beyond which one cannot go for the sea service is a hard service and fittings do not get an easy passage.

Aluminium

The use of aluminium and its alloys for both structural work and fittings is at first sight most attractive but there are many snags in its use. Not the least is the problem of supply, for the aircraft industry makes heavy calls on our aluminium supplies, which at their best are not profuse. Nevertheless, considerable progress has been made in obtaining aluminium alloys immune to sea-water corrosion and I look forward to increasing use of this material in future warships.

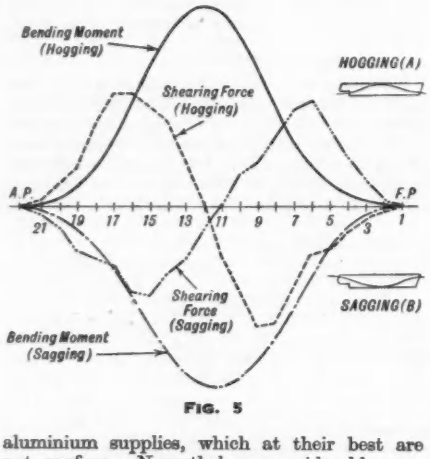


FIG. 5

Machinery

Though strictly the province of the engineer, the constructor has a controlling interest in this item, for apart from the question of speed and power, the constructor has to exercise close control on the weight and space allocated.

The weight and arrangement of propelling machinery depends on the power required to give the desired speed and on the type of machinery. As to type of machinery, the steam turbine holds the field where very large powers combined with relatively low weights are required.

The replacement of the reciprocating engine by the steam turbine with consequent saving of weight and space and increased efficiency was a notable advance. The introduction of gearing, made possible by advances in engineering practice, by reducing the propeller revolutions, considerably improved the performance, so that the geared turbine is now a standard installation. Improvements are continually being made both in turbines and gearing, and good progress is now being made with the adoption of double reduction gearing. Efforts are also being made to work to much higher temperatures, i.e., greater degrees of superheat, and higher pressures than hitherto.

The question of the reliability of machinery has to be carefully considered, and it is generally agreed that reliability under all conditions of temperature, weather and sea is the criterion to which we must work in our warships, which are required to operate if necessary in the tropics and also in polar regions. Now this has to be paid for in weight and in the past some foreign naval powers have installed far less robust machinery suitable only for the particular field of operations they had in view; for example, Italian ships in the Mediterranean. There can be no doubt that reliability is a fact which we cannot afford to put in second place, but, at the same time, we must pay the price—less weight available for other items.

There is another field which is being opened up, the internal combustion or gas turbine. At the moment we are experimenting with small units for ship propulsion, to examine fully the possibilities the gas turbine offers, among which are reduction in weight and space.

Diesels

Great progress has been made in recent years with the comparatively light diesel engine for surface vessels. The great advantage of the diesel engine is, of course, its greater overall efficiency, the consumption of fuel being considerably less than that of the steam turbine. But the great weight and large space at present required make the diesel engine an impracticable proposition when more than moderate powers are required, and it suffers the further disadvantage of being noisy and inducing considerable vibration. The smaller-sized diesel, with gearing, has, however, advantages in reliability and ease of maintenance and is still undergoing considerable development.

(*b*) Dynamos

The provision of adequate electrical power presents another headache for the constructor. The ever-increasing demands of modern complex fire-control arrangements, wireless, radar, &c., has necessitated considerable increases in the dynamo power of our ships. At the same time, provision must also be made for the possibility of loss of power in action due to damage, so in addition to the turbo-generators a number of diesel generators dispersed about the ship are carried.

Auxiliaries

Other items of machinery which are important in a warship are the evaporators and distilling plant for replenishing the fresh water tanks for domestic purposes. The steering gear requires reliable machinery with an alternative in case of power failure. Pumps are required for many purposes, particularly for pumping out flooded compartments in action, for maintaining pressure in the fire main; these all eat into our capital—displacement.

A ship must be self-supporting as far as food is concerned, and a certain amount of perishable foodstuffs must be carried. This entails the provision of a number of refrigerated spaces. Refrigeration plant must also be provided for air conditioning. This is particularly important in ships destined for operations in the tropics. Refrigerating machinery is thus becoming an ever-important item in the make-up of a ship.

Fuel

Oil fuel is now universally used for warships, and for design purposes it is considered as a separate group weight—it often contributes more to the displacement than the machinery itself! The use of oil for boiler fuels has many obvious advantages over the use of coal, and so long as supplies of oil of the requisite quality can be held to be reliable, we are unlikely to revert to the use of coal even with its modern applications. Looking to the future, the time is not perhaps too far distant when it will be unnecessary to carry fuel in the ordinary sense of the term in warships. This will bring with it far more difficult problems than we have hitherto encountered in design, but I am confident that our constructors will be equal to the task, and we shall not lag behind other nations in these developments.

The quantity of fuel required is dependent on the endurance required of the ship, i.e., the steaming distance which can be covered at a certain speed without refuelling. This, of course, is primarily governed by strategical considerations and availability of naval bases. Endurance is increased for a given quantity of fuel by improvements in machinery performance or the quality of the fuel itself. Experience in the last war showed that refuelling at sea whilst under way was a practical proposition, and this factor will simplify to some extent the question of providing sufficient oil fuel in regions where naval bases are few and far between.

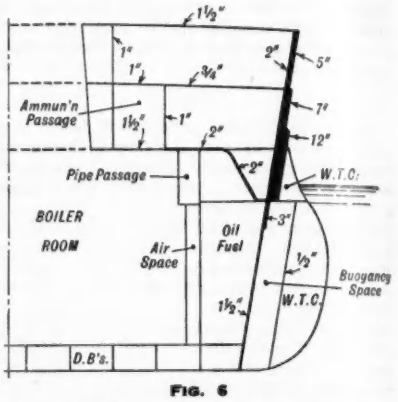


FIG. 6

Armour and Protection

The remainder of our capital after the allocation of the necessary weights to the items I have already described can be largely devoted to armour and protection of the ship generally. If we draw up our account for the various types of warship we shall find that in the case of a destroyer we have nothing to spare for armour and all that we can do in these ships is to provide a certain amount of bullet-proof plating for protection of exposed personnel. Other types of warship can carry various amounts of protection; battleships, for example, can spare about 30 per cent of their weight for this item.

The principles to be followed when considering the distribution of armour and protection are (i) that the extent of damage by a weapon should be kept to a minimum, (ii) that the entry of water, as a result of damage, into the ship, should be kept to a minimum.

With regard to the first of these, the designer has three main types of attack to provide protection against:

(*a*) Protection against shell.

(*b*) Protection against attack from the air.

(*c*) Underwater protection against mines and torpedoes.

The demarcation between the three is not clear cut. Each, in turn, affects the others in meeting the special requirements for which they are provided.

The Citadel

In order to simplify the arrangement of protection as much as possible and keep the weight of armour to a minimum, all the vital portions of the ship, magazines, machinery, control rooms, &c., are grouped together as far as possible in what amounts, in large warships, to an armoured box, which we term "the citadel." In addition, a certain amount of local protection is provided around such items as steering gear and bridge positions. This grouping of all the important compartments within the restricted citadel constitutes a severe test of the

skill and ingenuity of the designer and affects the arrangements of the ship as a whole.

(a) Protection Against Shell

The struggle between the gun and armour for supremacy is time-honoured. In the process of evolution the quality of armour plate has been improved and at times armour has had the advantage of the gun; but such advantage has been very temporary and for many years the gun, by virtue of its increased calibre, and the use of improved propellants, has definitely defeated the armour plate and it must be said that although improvements continue to be made there does not appear to be any prospect of a radical improvement in the quality of armour plate such as was brought about by the discovery of the process of face-hardening. Armour to defeat the modern shell would have to be of impracticable thickness but at the same time it should be borne in mind that the shell is unlikely to be the primary method of attack in the future.

(b) Protection Against Attack From the Air

Protection against attack from the air has become of increasing importance, until it is probably true to say that to-day this consideration is more important than the provision of protection against shell fire, since with the advent of guided missiles and rocket projectiles, aircraft can attack at greater ranges and the possibility of attacks of this nature are thus correspondingly increased. Protection can only be provided satisfactorily by deck armour. I think you will appreciate something of the problem confronting the designer who, with a given weight of armour, must provide the maximum protection against shell, principally by side armour, and the maximum protection against bombs, &c., principally by deck armour. This is where the full-scale experiments I mentioned earlier have been particularly valuable, enabling us to determine the most satisfactory distribution of armour.

(c) Underwater Protection

The record here, again, is one of continual struggle between the torpedo and the mine on the one hand and protection on the other. The fight is perhaps not so time-honoured and there is not at present the disparity between them which prevails in the case of the gun versus armour. In general it may be said that so far we have been able to meet probable underwater attack.

The large explosive charges of torpedoes and mines, whose effects are greatly intensified by the fact that the explosion occurs considerably below the water line, cause very serious damage. The aim of underwater protection is to keep the explosion outside the ship proper.

This was originally done by adding bulges to the ship's structure. Later the "Hood" was designed and built with external bulges (Fig. 6). Modern capital ships have an internal bulge incorporated within the ship, bounded on the inside by a thick protective bulkhead.

In essence all such schemes consist essentially of an outside buoyancy chamber in which the explosive gases may expand and inner chambers to absorb the shock of the explosion. Some of these chambers can be usefully employed for stowing the fuel and this increases the efficacy of the protection system.

Fig. 6 shows another feature of all large warships, the double bottom, which affords some protection from an explosion under ship, contributes to the strength of the ship and provides a useful stowage space for fuel.

General Equipment Weights

Finally we have a group comprising anchors and cables, boats, masts and spars, fresh water, provisions, stores and the crew—quite a considerable item.

You will not be surprised to learn that with present-day welfare requirements the weight under this heading constantly tends to increase. Far more attention is now given to the question of habitability under all climatical conditions than has hitherto been the practice. The experience of the last war in this respect was generally not happy. Never before was there such a spate of new inventions, which it was desired to embody as soon as possible in our warships; particularly was this the case in radar development. The difficulty is not only that this equipment occupied space which was originally intended for the accommodation of the crew, but at the same time additional numbers were required to operate and maintain the new equipment. The result was that in general all our ships were seriously overcrowded and it may well be that in future the size of our ships will be determined largely by the accommodation question.

American Engineering News

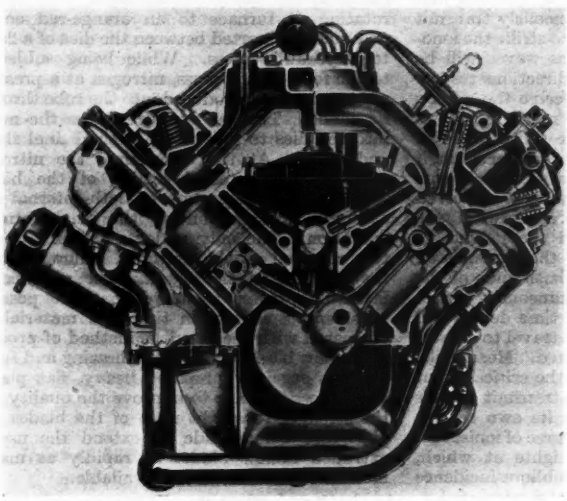
(From our American Correspondent)

A Powerful Automobile Engine

With its 1951 car models, the Chrysler Division of the Chrysler Corporation, Detroit, Michigan, has introduced what is the most powerful passenger car engine in production in the United States to-day. Known as the "Fire Power" engine, this power unit, which is illustrated herewith, is a 90 deg. vee eight-cylinder unit and develops 180 b.h.p. at 4000 r.p.m. This engine, with only 2·3 per cent additional displacement, has a maximum horsepower 33 per cent greater and a maximum torque 16 per cent higher than its predecessor, the 1950 Chrysler in-line eight-cylinder engine. The following table shows a comparison of the more important dimensions and characteristics of the two engines :—

	1950 In-Line 8 Side valves	1951 V–8 Overhead valves
Valve arrangement		
Bore, in	3½	3 11/16
Stroke, in	4½	3⅝
Displacement, cu in	323·5	331·1
Compression ratio	7·25	7·50
Max. torque, lb-ft	270	312
Max. b.h.p.	135	180
B.h.p. per cu in of displacement	0·418	0·544
Weight of engine assembly, dry, lb	722	700

The engine employs hemispherical combustion chambers, which, together with the lateral high-lift valve arrangement, has permitted the use of direct, free-flowing intake and exhaust ports and of large valves. At the same time, the spacing of the valves allows full circulation of the cooling water around the valve ports. Within the combustion chamber, the valve lay-out facilitates a short, direct port with a very low restriction, allowing the hot exhaust gases to pass freely into the manifold with a minimum of heat transfer through the walls of the port. Although the horsepower of the V-8 unit is 33 per cent greater than that of the in-line engine, the radiator core area has been reduced approximately 18 per cent due to the lower transfer of heat to the cooling water. The fan diameter, the number of fan blades and the fan speed have also been reduced accordingly. In comparison with the 4½in stroke of the in-line engine, the stroke of the V-8 engine is 3⅝in; hence the maximum piston speed has been decreased by more than 25 per cent, producing a corresponding reduction in frictional loss. A further reduction in sliding friction has resulted from the incorporation of a three-ring piston. Two narrow compression rings are used in conjunction with a single oil ring designed with narrow contact lands and a wide drain groove. Expansion is controlled at all operating temperatures by the steel strut construction of the piston skirt. The 90 deg. vee engine is inherently balanced dynamically with respect to both primary and secondary forces and secondary couples; the primary couple is counterbalanced by six large crankshaft counterweights. Since there is no unbalance of significant magnitude from higher order forces or couples, the balance of the engine is considered to be very satisfactory by the makers. The overall length of the crankshaft is $26^{9}/_{32}$in, as compared with $37^{17}/_{32}$in for the 1950 in-line engine. According to the makers, the maximum torsional stresses in the shaft are relatively insignificant throughout the operating speed range of the engine. Quietness of operation is ensured by a torsional damper incorporated at the front end of the crankshaft to eliminate the audible effects of minor torsional vibations. The camshaft used in the new engine is short and stiff and is supported by bearings situated in the cylinder block webs. With the aim of achieving quiet valve operation hydraulic tappets are being employed; they compensate automatically for variations in the length of the valve drive train, resulting from temperature changes, and thus maintain positive contact at all times throughout the train, from the cam surface to the valve stem.



Chrysler V-8 Engine

A Mobile Ionospheric Research Unit

The Central Radio Propagation Laboratory of the National Bureau of Standards collects and analyses ionospheric data from stations all over the world. From the data the Bureau compiles and publishes predictions of usable frequencies for communications between any two places at any hour. In an effort to obtain more comprehensive data on the ionosphere, the Bureau has now incorporated a mobile ionospheric research unit into the existing chain of sixty world-wide ionosphere stations, approximately one-fourth of which are maintained by the Bureau. With this new unit ionospheric soundings will be made from points midway between two permanent transmitting-receiving stations. This information will be used in studies of ionospheric effects on wireless waves directly above the mobile transmitter-receiver, and it will also help in analysing the behaviour of wireless waves propagated from transmitters to distant receivers. The mobile unit might more properly be called an ionosphere research caravan because it is made up of two prime movers and two trailers. The equipment includes two petrol-powered motor-generators that will provide 10kW each for the transmitting, receiving and recording components in the event of commercial power not being available. One of the trailers has been converted into living quarters for the two-man operating crew for use in regions where living accommodation cannot be obtained. The first recording stop of the caravan, 30 miles east of Cincinnati, Ohio, is a point midway between the Bureau's transmitting station at Sterling,

Virginia, and a leased transmitting station operated by Washington University, St. Louis, Missouri. The project, known as the "St. Louis Experiment," is expected to continue for three or four months. When the experiment is completed the unit will be moved to another centre point site. Within a few years and after a number of midpoint locations, the Bureau expects to have sufficient information about the ionospheric radio propagation to map accurately the paths of wireless waves across the country and into other parts of the world.

During the past twenty years the technique of vertical-incidence ionosphere soundings by the use of pulse transmitters scanning over a wide frequency range has been adopted internationally for recording the virtual height and degree of ionisation for each of the ionosphere layers. The St. Louis experiment and all of those to follow are designed to record simultaneously both vertical and oblique incidence data and, from an analysis of the information, the relation between oblique and vertical incidence reflectors will be more exactly deduced. In the St. Louis experiment the Sterling and St. Louis stations will simultaneously transmit pulses of radio energy directed to strike the ionosphere obliquely. The wireless waves will be propagated in west and east directions respectively, and each station will receive the other's signals. Because the pulses must travel up to the ionosphere and then be reflected down again, the travel time will be greater than if the signals were travelling directly along the surface of the earth. From the time delays involved the time of ionospheric travel between the stations will be obtained and the heights of reflection calculated. During the transmisson the radio frequencies used at both ends of the paths will be slowly but simultaneously varied. At the higher frequencies the time delays will be greater because these waves travel to greater altitudes before they are reflected. Meanwhile, the mobile station situated at the critical point of the propagation path will transmit signals vertically upward and receive its own echoes. By recording the heights and degree of ionisation of the several layers, the heights at which, according to simple theory, the oblique incidence signals should be reflected, can be calculated.

All three transmitting-receiving stations will use the model C-3 automatic ionosphere recorder which has been developed by the Bureau. Its transmitted power is 20kW and it is capable of scanning a frequency range of 1 to 25 megacycles per second in a time interval as small as 7·5 seconds. Signals will be transmitted, received and recorded on film strips on a twenty-four-hour per day basis. The St. Louis experiment involves comparatively short distances. However, it is known that the discrepancies between theory and practice increase in magnitude as the distance between transmitter and receiver becomes greater. To investigate this effect the mobile unit will be placed at the midpoint of much more widely spaced permanent installations. The next stop may be between the Sterling station and one in the Hawaiian Islands, Alaska, San Francisco, Puerto Rico or Panama. Before the project is completed the mobile unit will have been placed at the midpoint of the path to most of the Bureau's ionosphere stations in the western hemisphere. The Bureau will analyse the film-strip records from each three-station experiment. The analysis is expected to shed more light on the causes of fading and explain the complete loss of a signal between the transmitter and the receiver. Thus, at the end of this unusual series of experiments, the Bureau hopes to be in a position to supply all the users of long-range communications with more accurate information for selecting the proper frequency to transmit intelligence over a certain path, at any particular time of the day and year.

Extrusion of Hollow Steel Propeller Blades

An important development in the hot-extrusion of steel has resulted in a new mass-production method of manufacturing one-piece, hollow steel propeller blades for high-speed combat and commercial aircraft. The process was developed by the Propeller Division of the Curtiss-Wright Corporation, of Caldwell, New Jersey, in co-operation with the Manufacturing Methods Branch of the Industrial Planning Division and the Propeller Laboratory of the Engineering Division, Air Material Command, at the U.S. Air Force Development Centre, at Adrian, Michigan. While the hot-extrusion of steel and of certain non-ferrous metals is not new, the process has so far been confined to the production of tubes, bars and other relatively simple shapes. Now, however, steel is being extruded into the complex shape and the tapered thickness required in the manufacture of propeller blades. The process consists of two extrusion stages and one drawing operation. 400-lb billets of chromium-nickel-molybdenum steel at white heat are extruded on a 5000-ton "Loewy" horizontal extrusion press through a die, which forms the shank of the propeller. The extruded billet is then reheated and returned to the press, in which a second die expands and tapers the shank. Final extrusion results in a seamless steel tube, with "ears" or flanges extending from shank to tip. The tip of the extruded tube is then flattened and sealed. It is heated in an electric rotating-pit furnace to an orange-red colour and quickly inserted between the dies of a 2000-ton hydraulic press. While being subjected to the force of the press, nitrogen at a pressure of 1100 p.s.i. is introduced into the tube through its shank. The gas pressure forces the metal into the dies to give it the desired final shape and twist. At the same time the nitrogen prevents any internal scaling of the blade. "Magnaflux" inspection of both internal and external surfaces follows the final forming operation. The only major machining operation required on the extruded hollow blade is the finishing of the shank. The new manufacturing process is stated to make possible considerable savings in time and material, as compared with the previous method of producing hollow blades by welding, brazing and forming two specially prepared heavy, flat plates. It has been possible to improve the quality and the strength-to-weight ratio of the blades and plans are being made to extend the use of extruded hollow blades as rapidly as manufacturing facilities become available.

A Large Wind Tunnel Drive

A 180,000 h.p. wind tunnel drive, which is said to be able to generate blasts of air at several times the speed of sound, is now under construction at the Schenectady works of the General Electric Company. The motor unit is being built for the National Advisory Committee for Aeronautics for installation in a new wind tunnel at the Ames Aeronautical Laboratory, Moffett Field, California. The installation will consist of four 45,000 h.p. motors arranged in tandem on a single shaft. Stated to be the largest of their kind ever built, each of the motors will weigh about 130 tons. The four-motor drive unit will have a peak one-hour output rating of 216,000 h.p. The two compressors to be driven by the unit will be approximately 17ft in diameter.

Steelworks Application of Television

An interesting example of the industrial use of wired television is now to be found at the works of the Babcock and Wilcox Tube Company, at Beaver Falls, Pennsylvania. The company is one of the pioneers of the continuous casting process for steel billets and has found the initial pouring operation to be extremely critical. Experience indicated that, to get sound billets, free of sponginess and air inclusion, the mould had to be kept charged to a certain exact level. Formerly it had been necessary to station a man directly at the mould-top to watch the pouring, ready to signal to the furnace operator some 50ft away. Thus, there was a certain possibility of misunderstanding, a high degree of hazard and extreme discomfort due to radiant heat. Now a television camera with a long focus lens is suspended above the molten metal surface in the mould. It transmits an exact, instantaneous and continuous picture of the molten metal level to a cathode-ray tube viewing screen, which is mounted in the furnace control panel, enabling the furnace operator himself to watch the pouring at close range.

French Engineering News

(From our French Correspondent)

Plans have been drawn up for the reconstruction of Paris Metro stations. The new scheme follows the American pattern, based on automatic turnstiles instead of the sale of tickets. The present gate barriers will not be difficult to rebuild to take the automatic turnstiles. Each control gate now costs between 300,000 and 400,000 francs a year in maintenance, and it is estimated that the cost of the change will easily be covered in a few years.

One difficulty is the choice of the coin to be inserted in the turnstiles; the single tariff is constantly changing in France. Another factor would be the dismissal of 3000 employees. Further Metro plans now under consideration include the building of a short line to form a second link from north to south.

Another line included in the project would link the central termini. It is estimated the cost of constructing the new lines would amount to one and a half milliard francs per kilometre.

* * *

At a Press conference the director of Electricité de France said that in the past three years water power generation had been increased by about 3000 million kWh. This total was below the figure set by the Monnet Plan. Steel shortage had been one of the reasons why the original plan had to be modified.

He said that the consumption of current in rural and industrial areas was growing constantly. The first three months of 1951 showed an increase of almost 2 milliard kWh over 1950, and over 4 milliards over 1938. He went on to say that now France had 344 hydraulic power plants which, in 1950, produced 16 milliard kWh. The potential output lay between 60 and 100 milliards so that no more than one-quarter of the country's water power potential was actually being exploited.

* * *

The French State Council, which is analogous to Britain's Privy Council, decided this week that the 220kV line between Paris and the Massif Central must be handed over to Electricité de France by the French railways. This line was built by the old Paris–Orleans Railway.

Following the nationalisation of the French electricity supply industry, the transmission line was given to the new electricity authority but the railways objected that the 220kV line, which fed the electric traction system, had already been nationalised through the nationalisation of the railways. The Government then decided to take the power line away from Electricité de France and return it to the railways.

Finally, Electricité de France decided to appeal to the Conseil d'Etat. It complained that the transmission line carried one-tenth of the total French electricity output, and that the railways used only 25 per cent of its throughput, the rest being sold to ordinary consumers. The Council therefore decided that the lines should be returned to Electricité de France.

* * *

Salvage work on wrecks is being assiduously carried out off the French coast. To date some 3000 tons of copper have been recovered. Work on the salvaging of several tons of sheet steel continues. The operations are in the hands of an Italian company, which is using vessels equipped with steel cupolas carrying ten 1000W projectors for illumination. With these projectors it is possible to examine the sea bed. Each cupola is occupied by a man who is in telephonic communication with the ship while the cupola is submerged, the maximum operating depth being 1200ft. The ships, which are working off the Brittany coast, dock at Morlaix every night. They have succeeded in salvaging some wrecks from the first World War.

* * *

The French Socony-Vacuum refinery at Frontignan is to be equipped with a new cracking unit with a capacity of 15,000 barrels daily. This unit is being designed to include very recent developments. It will stand 261ft high and will be the first of its kind to be built in Europe. It will come into operation in a few months.

Industrial and Labour Notes

The European Engineering Industry

The United Nations Economic Commission for Europe has published this week a comprehensive report entitled "A General Survey of the European Engineering Industry." It has been prepared by the Commission's industry and materials division, in consultation with Government and industry officials, but nevertheless claims to be a completely independent analysis. The survey is divided into eight chapters entitled :—The Importance of the Engineering Industry in the European Economy; Trend of Production; Pattern of Trade; The European Engineering Industry by Sectors; The Engineering Industry by Countries; Trends in Specialisation Between Countries and in Sectors; Possible Course of Demand in Certain Regions; and Some Lines of International Action.

The report stresses the basic economic and social importance of the European engineering industry, pointing out that it accounts for roughly one-sixth of the total industrial employment in Europe. From 50 to 60 per cent of the steel industry's output, it is observed, is absorbed by or depends directly on the level of operation in the European engineering industry. In 1948, the report shows, engineering products accounted for approximately 15 per cent of the total value of intra-European trade, and for 30 per cent of Europe's total overseas exports. In 1950, indices of general engineering production were 116 per cent above pre-war in Poland, 100 per cent higher in the U.S.S.R. and 93 per cent higher in Czechoslovakia. In Western Europe increases were substantial, though less spectacular, indices of production rising 62 per cent in the United Kingdom and 24 per cent in France. All other countries in the western group, the report asserts, also exceeded their pre-war output, apart from Western Germany, where in 1950, although production was expanding rapidly, it was still 14 per cent below pre-war.

Referring to variations in demand, the report notes that engineering products directly affected by defence orders, such as road transport equipment and machine tools, are already becoming short. A large and increasing range of other engineering products directly or indirectly affected by defence orders is likely to become short. Yet, the report continues, it seems probable that the underlying weakness of demand for a wide variety of products, which began to show itself a year or more ago, and thus the ultimate need to seek new outlets for European engineering goods, remains hidden below the surface. About lines of international action, the report says that the engineering industry's output in all European countries has increased, in some cases considerably, compared with pre-war. But, during broadly the same period, the U.S.A. has considerably increased its lead over the engineering industries in Europe, the U.S.S.R. being the only exception. The main explanation of the competitive advantage of the U.S.A. in the engineering field must be sought, the report comments, in the reasons for its high productivity. Clearly, it is suggested, there is scope for more concerted international examination of the problem of improving the productive efficiency of the European engineering industry.

Control of Nationalised Industries

The Electrical Trades Union is holding its annual conference at Hastings this week. Its agenda contains 144 resolutions, covering a variety of subjects. Eleven of the resolutions are concerned with the nationalised industries generally and with the British Electricity Authority in particular. One of them notes with regret that "in spite of repeated protests from trade unions representing workers employed in the nationalised electricity supply industry, the Minister of Fuel and Power still denies the workers the right of direct representation in the management and control of that industry."

Another resolution calls upon the union's executive council to review the activities of the British Electricity Authority and its Area Boards, which continue "to operate in a manner very little different from pre-vesting days." It is urged that "a greater agitation is needed to bring about a change of attitude." There is also a resolution which expresses concern about "the ever-growing increase in non-productive personnel in the nationalised electrical industry, which results in increased administrative costs."

Labour for Ordnance Factories

The Ministry of Supply has estimated that approximately 50 per cent more labour will be needed by this country's twenty-one Royal Ordnance Factories to carry out work on the rearmament programme. It is stated that between 15,000 and 20,000 workers will have to be found as production increases. The Ministry says that roughly two-thirds of that number will be required in the Midlands and the North, the remainder being wanted, in fairly equal proportions, in Scotland, Wales and the South. Women are being sought for light engineering and for work in the explosives and ammunition-filling factories. The particular shortage is of skilled men, especially machine tool operators, fitters, electricians and carpenters.

Schemes for the employment of part-time women workers are now being considered by the Ministry. Elderly workers are also to be sought, provided that suitable jobs are available.

Index of Industrial Production

The index number of industrial production (1946=100), which is prepared by the Central Statistical Office, has been estimated provisionally at 150, for all industries, for February, compared with 141 for January. Figures for the corresponding months of 1950 were 140 for February and 135 for January. The provisional figure for all industries for February this year is, therefore, about 7 per cent higher than the figure for February, 1950, but the manufacturing industries showed an 8 per cent increase. On the basis of information so far received, the index figure for all industries in March is expected to be 141 or 142. Last year it was 144, but it must be remembered that this year the Easter holiday fell in the month of March.

Industry in London and S.E. England

At a meeting last week of the London and South-Eastern Regional Board for Industry, serious concern was expressed about the continuing cuts in electricity supplies. These cuts, it was stated, had caused considerable loss of production to industry in the region. The Board recommended that the electricity generating industry should be considered next in importance to the coal industry for the allocation of raw materials, particularly steel. It was also suggested that electricity maintenance workers from industry should be encouraged to work week-end shifts at power stations to relieve British Electricity Authority staffs.

Raw material shortages were again discussed. The Central London District Advisory Committee expressed anxiety about the increasing scarcity and rising prices of raw materials and urged that there should be tighter control to ensure fairer distribution of available stocks. The Board of Trade reported that the number of applications for assistance in connection with supplies of copper and zinc had not been so great as had been anticipated, and that, in fact, more concern was being shown about future supplies of iron and steel.

Another matter reported to the meeting related to London firms desirous of moving to new towns and L.C.C. estates. An investigation had revealed that of eighty-two schemes approved for such removal, thirteen had been completed and twenty-two were under consideration.

The Coal Situation

The Minister of Fuel and Power, Mr. Noel-Baker, stated in the House of Commons on Monday last that in the first seventeen weeks of this year, ended April 28th, coal output from the deep mines totalled 71,321,700 tons, compared with 68,244,000 tons in the corresponding period of last year. The increase in 1951 over 1950 had therefore been 3,077,700 tons, to which, the Minister said, every division of the National Coal Board had contributed.

The Minister added that the average number of workers in the pits during the first four months of this year was 6500 less than in the corresponding period of 1950. He hoped and believed that the investment programme of the Coal Board was giving constantly increasing results. Saturday working, the Minister suggested, was certainly giving a large part of the additional deep-mined coal; and the output per man shift, although it tended to be reduced by Saturday working because of the short shift, had nevertheless been 3 per cent higher than last year.

Die Casting Productivity Team

A productivity team to study die casting sailed last Tuesday for the U.S.A. Arrangements for the tour have been made by the Anglo-American Council on Productivity, and the team has been constituted from those engaged in the zinc and aluminium pressure and gravity die casting industries. Mr. C. R. Lyons, of the Imperial Smelting Corporation, Ltd., is the leader of the team.

The manufacture of castings in permanent and semi-permanent moulds has been developed to a far greater extent in the U.S.A. than in Europe, and American industry, it is stated, makes greater use of these highly productive methods. It is believed that not only is die casting more widely used in the U.S.A. than in the United Kingdom, but also that greater productivity is achieved in the manufacture of similar components. During its visit, the team will be engaged primarily in seeking the reasons for these two differences.

Non-Ferrous Scrap Prices

The Minister of Supply has made the Non-Ferrous Metals (No. 4) Order, which consolidates earlier Orders, revises certain maximum prices of scrap, and provides for special prices for exceptional transactions. The Order came into force on May 4th.

The new prices permitted by the Order are as follows :—Secondary zinc alloy ingots to B.S.S. No. 1141, £177; No. 1 copper wire, £183; clean heavy copper, £178; No. 2 copper wire, £173; braziery copper, £156; lead cable sheathing scrap, £147; lead scrap other than cable sheathing, £143; zinc alloy die casting not free from inserts, £129; S.A.A. cases mechanically treated or fired, £173. Other changes permit bona-fide scrap metal merchants to charge a commission of 1½ per cent on remelted lead, and to increase the maximum charge for briquetting to £2 per ton. In addition, the maximum price for scrap not mentioned in the Order may be fixed by agreement between the buyer and seller. The agreed price, however, must not exceed the highest scheduled price for material in the same class.

Provision is also made for special prices for scrap chemical lead and for scrap produced in technical colleges, and for the Minister to authorise special prices for scrap which has to be sorted to unusual requirements.

Notes and Memoranda

Rail and Road

BRITISH RAILWAYS CHAIRMAN IN U.S.A.—Mr. John Elliot, chairman of the Railway Executive, is on a short visit to the United States, where he will meet the executive heads of several of the largest American railroads, and will inspect the British Railways organisation in the U.S.A. for development of tourist traffic to Great Britain.

POST OFFICE (LONDON) RAILWAY.—Mr. A. A. Golding has retired from the position of manager of the Post Office (London) Railway. He was appointed chief traffic inspector in March 1926, after nineteen years' service on the Metropolitan District Railway, and was responsible for the training of the postal operating staff specially recruited when the line was first opened for the conveyance of mails in December, 1927. Mr. Golding became manager of the railway in 1936. Mr. W. D. McLaren succeeds Mr. Golding as manager. He joined the Post Office Railway as an engineering inspector in September, 1929, to train the engineering staff on the special equipment.

THE CANADIAN PACIFIC RAILWAY.—In the course of his address at the recent annual meeting of the Canadian Pacific Railway, the president, Mr. W. A. Mather, said that last year the company spent 47,000,000 dollars on additions and improvements to its railway properties, bringing the total since the end of the war up to 213,000,000 dollars. The demands now being made on the railways—which were likely to grow with the mounting defence effort—placed a great strain on available facilities. The importance to the national welfare of a far-sighted policy with respect to the financial needs of the railways was therefore doubly emphasised. Net railway earnings in the first quarter of this year, Mr. Mather continued, had increased 4,700,000 dollars over the same period of last year, but the comparison was with a period in 1950 which was adversely affected by unusually bad weather conditions. The costs arising out of settlements with operating groups of employees were included in expenses of the first quarter, but the cost of the forty-hour week had yet to be met. Despite some probable increases in traffic volume, it was clear that to maintain even the comparatively low level of net earnings of 1950 prompt and adequate increases in freight rates must be approved.

Miscellanea

EXPORT LICENSING CONTROL.—Under an Order made by the Board of Trade, with effect from May 14th, licences will be required for the export to all destinations of many additional descriptions of iron and steel, wire and strip of copper or copper alloy, and fibre building board.

A BRITISH BROADCAST TRANSMITTER FOR SWEDEN.—Broadcasting services in Sweden have been augmented by a new medium-wave transmitter which was recently installed at Gothenburg by Standard Telephones and Cables, Ltd. The transmitter has a power output of 150kW with two radiators giving a directional field pattern with maximum field strength on the landward side, and minimum output towards the sea. To minimise interference the signal is reduced in the direction of N.W. Africa, where there is a transmitter working on the same frequency. Gothenburg station, which was built in 1925, was originally equipped with a 500W transmitter; in 1928 it became a 10kW station, serving a population of about 400,000; with the new transmitter it will serve a public of about 750,000. In each of the installations all the transmitter equipment was supplied by Standard Telephones and Cables, Ltd.

THE INSTITUTION OF ENGINEERS-IN-CHARGE.—The forty-sixth annual dinner of the Institution of Engineers-in-Charge was held last Friday evening, May 4th, at the Holborn Restaurant, London. A large company of members and guests assembled under the able chairmanship of Mr. Robert Chalmers, M.I.C.E., President of the Institution. All of them were particularly happy to be welcomed by Captain A. E. Penn, who is now in his fortieth year as honorary secretary of the Institution, and who was, as usual, mainly responsible for the excellent arrangements made for the dinner and entertainment. The toast of "The Institution" was proposed by Mr. H. W. Swann, M.I.E.E., H.M. Senior Electrical Inspector of Factories, who spoke of the changes over the years in engineering practice and emphasised the importance of close co-operation between engineers-in-charge with mechanical and electrical engineering experience. After a gracious response by the President, the toast of "Our Guests and Friends" was proposed by Sir William Larke, the immediate Past-President, who referred to the Institution's indebtedness to senior institutions, whose members designed and provided the tools which engineers-in-charge used so well. Reply was made by Mr. H. R. Binney, director and secretary of the British Standards Institution. The final toast was "The President." It was proposed by Mr. F. E. Shaw, Chairman of the Institution, and was warmly endorsed by the company. An orchestral and vocal entertainment added much to the pleasure of the evening.

OBITUARY.—We record, with regret, the death of Mr. Arthur Reginald Dyer, A.M.I.C.E., which occurred on May 4th at his home at "Wynchmore," Filsham Road, St. Leonards-on-Sea. Mr. Dyer, who was seventy-three, served with the London Fire Brigade for nearly thirty years, and was chief officer for fourteen years, until his retirement in 1933. . . . We have also learned with regret of the death of Mr. Oswald H. Wass, chief sales representative of General Refractories, Ltd., Sheffield. He had been with that company since 1924.

INSTITUTION OF MINING AND METALLURGY.—The Institution of Mining and Metallurgy has conferred honorary membership upon Sir Henry Tizard, F.R.S., in recognition of his outstanding services to science, and on Sir Andrew Bryan, H.M. Chief Inspector of Mines, in recognition of his distinguished services to the mining industry of the United Kingdom. The Consolidated Gold Fields of South Africa Ltd. Gold Medal has been awarded jointly to Mr. J. P. Norrie and Mr. W. T. Pettijohn, for their paper on "An Outline of Underground Operations at Mufulira Copper Mines, Ltd., and the 1950 premium of forty guineas has been awarded jointly to Mr. H. L. Talbot and Mr. H. N. Hepker, for their paper on "Investigations on the Production of Electrolytic Cobalt from a Copper-Cobalt Flotation Concentrate." Mr. G. J. Mortimer has gained the William Frecheville Students' Prize for his paper on "Grade Control."

PURCHASING OFFICERS ASSOCIATION.—The Purchasing Officers Association is organising a Scottish and North of England one-day conference at the North British Station Hotel, Edinburgh, on Saturday, May 19th. The programme will include papers on "The Purchase of Castings," by Mr. F. J. White, of Chance Bros., Ltd., and on "Economic Efficiency," by Mr. A. Elliott, of the Churchill Machine Tool Company, Ltd. There is also to be a Brains Trust on purchasing topics, while group discussions running concurrently will consider such subjects as "Reciprocal Trading," "Material Controls and Priorities" and "Purchasing Publications." Although the conference is primarily intended for members of the Association's branches in Scotland and on Tyneside, any other purchasing officers will be welcome to attend and should apply for tickets to the General Secretary of the Association, Wardrobe Court, 146a, Queen Victoria Street, London, E.C.4. The charge of 12s. 6d. will cover attendance at the luncheon, as well as participation in all conference sessions.

JUNIOR INSTITUTION OF ENGINEERS.—On April 27th, at the Connaught Rooms, the Junior Institution of Engineers held a dinner to celebrate the sixty-seventh anniversary of its foundation. As usual, the President was called upon during the meal to take wine with selected guests, groups of members, representatives of the Press, &c., although Mr. Tookey, who has for so many years in the past acted as Honorary Toastmaster, was, to his and to the members' sorrow, unable to be present. After dinner the toast of "The Institution" was proposed by Dr. Livingstone Smith, who remarked upon the danger educationally of laying too much stress on academic attainments and not enough on practical ability. Was our present system of education as perfect as it might be? He thought it catered only for those with a particular type of mind who could get through examinations. Many good engineers had had great difficulty in getting through examinations and many of such men now occupied important posts. Mr. P. B. Herbert, Chairman of the Institution, replied. The toast of "Research and the Marine Engineer," was breezily proposed by Air Commodore Banks, who pretended to know little about engineering, but turned out to know a very great deal, and Engineer Rear-Admiral Hoare replied. Mr. Pillinger, Vice-Chairman of the Institution, then proposed the toast of "The Guests," and Sir George Nelson, in his reply, remarked that theory was a "bag of tools and technology was the use of theory for practical purposes." Finally, Mr. Broderick, Vice-Chairman of the Institution, proposed the toast of "The Chairman." When Mr. Herbert had replied proceedings came to an end.

Personal and Business

MR. H. R. LUPTON, M.A., M.I.Mech.E., has resigned his position as mechanical engineer of the Metropolitan Water Board.

W. FLANAGAN AND SON, Ltd., announces that it has begun building a modern factory on the Fazakerley Trading Estate, Liverpool.

DR. C. F. BAREFORD, head of the Mullard Electronic research laboratory, has been appointed a director of Mullard Equipment, Ltd.

THE REGIONAL ADVISORY COUNCIL FOR HIGHER TECHNOLOGICAL EDUCATION has changed its address to Tavistock House, South, Tavistock Square, London, W.C.1.

MR. VERNON L. FARTHING, M.I.Mech.E., has been elected vice-president of the Liverpool Engineering Society and president of the Liverpool Metallurgical Society.

HEENAN AND FROUDE, Ltd., states that Mr. A. H. Langford, director and general manager, has been appointed a director of its subsidiary, The Morton Machine Company, Ltd., Wishaw, Scotland.

BOYLES BROS. DRILLING COMPANY, Ltd., has changed its address to John Street Works, South Gosforth, Newcastle upon Tyne, 3 (telephone, Newcastle upon Tyne 53971; telegrams, Boylbro, Newcastle upon Tyne).

MR. P. M. OTWAY, M.I.Mech.E., has retired from the chief engineer's department of the Ministry of Transport, and has joined Major H. E. Aldington, C.B., M.I.C.E., in consulting practice at 47, Victoria Street, Westminster, S.W.1.

MR. R. G. SIMPSON has resigned from the chairmanship and from the board of Boulton Paul Aircraft, Ltd., owing to the pressure of other duties. Mr. J. D. North has been elected chairman and will continue in his office of managing director.

MR. V. J. CHALWIN has relinquished his office as managing director of J. and H. McLaren, Ltd., Leeds, to become managing director of the Associated British Oil Engines Group activities in Australia. Colonel H. T. Thornley has succeeded him as managing director of J. and H. McLaren, Ltd.

THE BRITISH BROADCASTING CORPORATION states that Mr. C. Buckle, A.M.I.E.E., has been appointed engineer-in-charge of the television transmitting station now being built at Holme Moss, near Huddersfield. His assistant is to be Mr. J. P. Broadbent, who is at present a senior engineer at the Droitwich transmitting station.

BURTON GRIFFITHS AND CO., Ltd., Marston Green, Birmingham, announces that, by mutual agreement, the agency arrangement, in Northern Ireland and Eire, with Messrs. Gilbert and Murphy has been terminated. Representatives from the head office of Burton Griffiths and Co., Ltd., will now deal with business in the area.

Contracts

NEW SOUTH WALES ELECTRIFICATION.—British Insulated Callender's Construction Company, Ltd., is to supply and install overhead equipment for electrification of the railway between Parramatta and Lithgow. The contract, which is valued at about £3,000,000, involves a total of 256 single-track miles, including four tracks between Parramatta and Doonside, and two tracks from Doonside to Lithgow, in the western coalfields area. The scheme forms an extension of the existing 1500V electrified system which connects Sydney and Parramatta, and it will cater for heavy coal freight trains.

DURING the past month the British Electricity Authority has placed contracts for equipment for power stations, transforming stations and transmission lines amounting in the aggregate to £2,488,233. The principal contracts include: Tilbury power station, 132kV, 3500MVA switchgear (Metropolitan-Vickers Electrical Company, Ltd.); Acton Lane "B" power station, Willesden, structural steelwork (Sir Wm. Arrol and Co., Ltd.); Brighton "B" power station, superstructure to administration block, garage and stores block (Holloway Brothers (London), Ltd.); Doncaster power station, coal-handling plant (Mitchell Engineering, Ltd.); Huddersfield power station, boiler plant (Bennis Combustion, Ltd.); Drakelow power station, near Burton-on-Trent, site and foundation works (Sir Robert McAlpine and Sons (Midlands), Ltd.); Doncaster to West-Melton 132kV overhead line (Watsham's, Ltd.), and Uskmouth-Llantarnam, 132kV overhead line (Balfour Beatty and Co., Ltd.).

British Patent Specifications

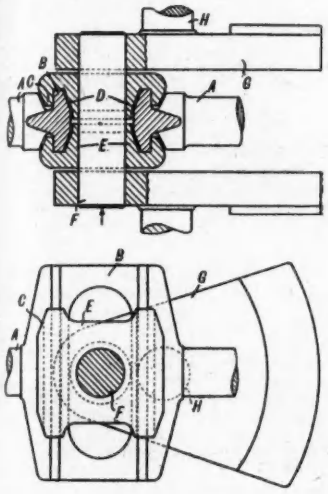
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

INTERNAL COMBUSTION ENGINES

651,894. February 20, 1948.—MECHANISMS FOR CONVERTING RECIPROCATING MOTION INTO ROTARY MOTION, Gilbert Edgar Manley, of Norton Curlieu, Warwick.

In the drawings the piston rods *A* are connected to the opposite sides of a rectangular and longitudinally slotted link *B*, the major axis of which is arranged at right angles to the axis of reciprocation of the piston rods. The sides of the link are embraced by the inwardly turned jaws *C* bounding oppositely disposed recesses *D* formed in a bearing block *E*, composed of two similar parts mounted on the crank-pin *F* connecting the crank cheeks *G*, which are secured on the main engine shafts *H*. The link *B* is provided with opposite and exter-



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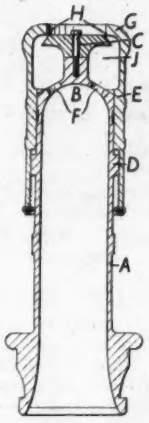
nally disposed longitudinal bearing surfaces, which co-operate with complementary bearing surfaces formed by the inner faces of the jaws *C* on the block *E*, so that the block and the link are associated in a sliding relationship to enable the reciprocating motion of the piston rods *A* to be converted into a rotary movement of the main shafts *H*. With the arrangement described it is found that the forces set up tend to move the leading edge of the block *E* away from the adjacent bearing surface of the link *B* so that there is no tendency for the leading edge to bite into the bearing surface.—*April* 11, 1951.

BURNERS AND SPRAYERS

652,140. October 29, 1948.—NOZZLE FOR PRODUCING SPRAY AND MIST, The General Fire Appliance Company, Ltd., of 11, Waterloo Place, London, S.W.1, and Eric Robert Fuller, of 2, Twineham Green, Woodside Park, London, N.12.

A very fine spray or mist of water or other liquid which can be thrown a considerable distance from the nozzle of a hose is needed for various purposes for fighting oil fires, for spraying fruit, for saturation and for smoke driving. The present invention provides nozzles from which the water is projected at high velocity in a converging annular jet. Referring to the drawing, the central tubular member *A* of the nozzle is about the same diameter as the hose from which it receives the supply. Its front is closed at *B* and is extended with a mushroom-like stem to an end piece *C* of somewhat less diameter than the tube, in the form of a frustum of a cone with a base angle approximately 57 deg. An external thread *D* is formed on the tube some way behind its closed end for the reception of an outer tubular member *E*. Between the external thread and the closed end of the central tubular member a number of apertures *F* are provided to permit the free passage of fluid from within. The outer tubular member has its front inwardly flanged at *G* in front of the frusto-conical end of the inner member. The inwardly extending flange may be of substantially rectangular cross-section as shown at *H* so as to present a single edge towards the end piece *C* of the inner tubular member, or it may be chamfered off internally to provide at its rearward end an annular surface parallel to the opposing face of the end piece. The dimensions of both members are such that an annular chamber *J* is formed behind the annular aperture between the forward ends. The fluid pressure within this chamber is supplied through the apertures in the



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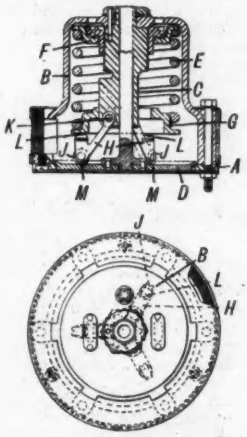
inner member. The arrangement is such that the outer member can be screwed down to close the annular aperture and adjusted to give the small clearance necessary for optimum results, but where conditions of volume and pressure of the fluid supply are sufficiently constant a permanent setting can be used. *April* 18, 1951.

VALVES

652,053. March 19, 1948.—PRESSURE RELEASE VALVES, Westland Aircraft, Ltd., of Yeovil, Somerset, and Angus Charles Marjoribanks Maitland, of the company's address.

This invention relates to means for modifying the effective rate of a spring when it is subjected to load. In a spring-loaded pressure release valve for maintaining substantially constant pressure in a contained space, shown in the drawings, there is mounted on a wall of the space a casting incorporating an annular valve seating ring *A* and carrying a domed cap member *B* bearing a tubular valve guide *C* for the spindle of a mushroom valve, the head *D* of which mates with the seating. A helical spring *E* within the domed cap bears at one end a flanged disc *F*, supported by a flanged nut on the valve



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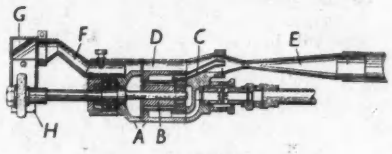
guide *C*, which is secured to the cap, and bears at its other end upon a flanged disc *G*. This disc bears against a set of three pivoted members *H*, each of which carries a roller *J* at its lower end resting against the valve head. These members comprise distance pieces pivoted at *K* at their ends remote from the rollers to the valve guide *C*, and each embodies an intermediate surface *L*, upon which the disc *G* abuts so that when the valve occupies its closed position axial pressure is exerted on the valve head by way of the parts of the members *H* lying between *L* and *M*. As the valve moves away from its seating into open position a compensating action is obtained as the levers tilt, to completely offset the increase due to spring rate and reduction of opening force, due to reduced static pressure on the valve head. At the same time the spring is compressed to a lesser extent than the amount of valve opening. Increase of compression load on the spring due to opening of the valve will approximately conform to a straight line curve, so that, by suitable arrangement of the members and choice of spring, a required degree of compensation for spring rate can be obtained.—*April* 18, 1951.

TOOLS AND WORKSHOP APPLIANCES

652,198. December 3, 1948.—TURBINE DRIVEN GRINDING WHEELS, Bata, narodni podnik, of Gottwaldov, formerly known as Zlín, Czechoslovakia.

In the drawing the casing *A* of the grinding device in which a rotor *B* is housed has, instead of the usual outlet openings, a nozzle *C* opening in a draw-off conduit *D* in the casing. One side of the draw-off conduit is connected to an exhaust pipe *E*. The other end is connected to a suction



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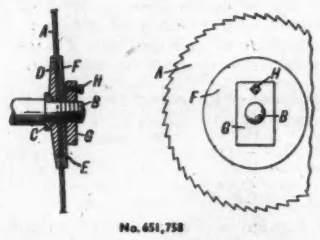
pipe *F* on which is mounted the hood *G* of the grinding wheel. Exhausting compressed air entrains the air from the draw-off conduit, the suction pipe and the hood and the dust formed during the grinding process is exhausted. The hood has an elastic tongue *H*, which during the working process is located near the grinding position so as to arrest the dust and deflect it towards the exhaust conduit. The hood, together with the suction pipe, is adjustable and in certain cases may be entirely omitted so that exhausting is performed through the draw-off conduit only.—*April* 18, 1951.

WORKSHOP TOOLS AND APPLIANCES

651,758. April 15, 1948.—CIRCULAR SAW MOUNTING, Paul Lister Wagner and John Ruben Rule, of Route 2, Box 555, Walnut Creek, and 920, Spruce Street, Berkeley, California, U.S.A.

This invention relates particularly to means for adjusting the angularity of a saw on its spindle, to cut grooves having different widths. Referring to the drawings, a circular saw *A* is assembled on a spindle, which has a reduced end portion *B*, which is threaded for the reception of a holding nut. This portion creates a shoulder against which lies a washer *C* having a convex side, which provides a complementary fit with a washer *D* of larger diameter.

The larger washer has a planar surface *E*, against which the circular saw lies. Another washer



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F of the same diameter, is fitted on the spindle on the opposite side of the saw. A plate *G* in the form of a rectangular nut threaded onto the spindle, has a set screw *H*, the inner end of which engages and bears against the washer. In effecting a desired angular adjustment of the saw, the nut is adjusted to a position on the spindle, which will permit of the desired angularity of the saw, following which the set screw is turned down to lock the assembly in the adjusted position.

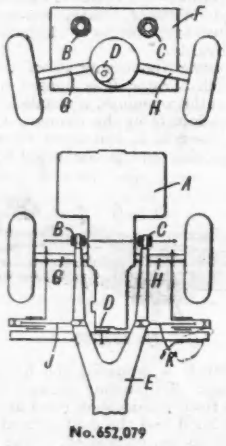
For lighter duty service the washer *F* is eliminated and the nut is replaced by a conventional nut and a plate of substantial area and triangular form with the set screw opening at the apex, thus leaving the base to provide a line contact engagement against the saw.—*April* 11, 1951.

AUTOMOBILE ENGINEERING

652,079. December 8, 1948.—AN ELASTIC MOUNTING FOR THE DRIVING UNIT IN MOTOR VEHICLES, Tatra, narodni podnik, of Koprivnice, Czechoslovakia, and Vladimir Korbel, of 1329, Na Rokytce, Praha VIII, Czechoslovakia.

As shown in the drawings, the driving unit *A* is supported at three points, *B*, *C* and *D*, by means of a fork which forms the end of a central tubular frame member *E*; but it is also possible to fix the

fork to the bodywork of the vehicle. Two suspension points *B* and *C* are provided at the end of each arm of the fork member. The end of each arm forms a cylindrical pin, surrounded by a rubber sleeve in a cylindrical casing supported in a transverse wall *F* in which the driving unit is suspended near its centre of gravity. The supporting pins at the end of both fork arms are substantially parallel to the longitudinal axis of the vehicle, so that it is possible to withdraw the driving unit from these supports when the third suspension is dis-



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engaged. The third suspension *D* is located by a detachable coupling, which connects the driving unit to the frame of the vehicle in such a manner that it not only forms a support for the driving unit, but also is adapted to withstand forces acting in the direction of the longitudinal axis of the vehicle. The driving wheels are directly connected to the driving unit by means of swinging half-axles *G* and *H*, which support the vehicle chassis by means of a spring suspension constituted by torsional rods *J* and *K*, the transverse forces being taken mainly by the supporting points *B* and *C* at the end of each fork arm. By this arrangement, it is claimed that the driving unit is safely supported and by disengaging the coupling formed by the central-suspension, the driving unit can be easily withdrawn from the frame of the vehicle.—*April* 18, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Association of Supervising Electrical Engineers

To-day, May 11th.—CREWE BRANCH: Crewe Arms Hotel, Crewe, "Motors and Control Gear," 7.30 p.m.

Sat., May 19th.—OXFORD BRANCH: Southern Electricity Board's Demonstration Room, George Street, Oxford, "Neon Sign Estimating, Erection and Maintenance by Contractors," H. Langdon-Down, 3 p.m.

Engineer Buyers' and Representatives' Association

Thurs., May 17th.—Imperial Hotel, Temple Street, Birmingham, Annual General Meeting, 8 p.m.

Institute of Road Transport Engineers

To-day, May 11th.—South Wales Institute of Engineers, Park Place, Cardiff, "Engine Bearings," 7 p.m.

Institution of Chemical Engineers

Fri., May 18th.—May Fair Hotel, Berkeley Street, London, W.1, Twenty-Ninth Annual Corporate Meeting.

Institution of Civil Engineers

Tues., May 22nd.—Great George Street, Westminster, S.W.1, Annual General Meeting, 5.30 p.m.

Institution of Electrical Engineers

Thurs., May 17th.—Savoy Place, Victoria Embankment, W.C.2, Annual General Meeting, Corporate Members and Associates only, 5.30 p.m.

Mon., May 21st.—LONDON STUDENTS' SECTION: Savoy Place, Victoria Embankment, W.C.2, Annual General Meeting, followed by a Film Show, 7 p.m.

Wed., May 23rd.—SUPPLY SECTION: Savoy Place, Victoria Embankment, W.C.2, "Hydro-Electric Power Development in Scotland," Sir Edward Maccoll, 5.30 p.m.

Institution of Production Engineers

Tues., May 22nd.—WOLVERHAMPTON GRADUATE SECTION: Technical College, Wolverhampton, "Metrology," G. H. Rutland.

Institution of Structural Engineers

Thurs., May 17th.—11, Upper Belgrave Street, London, S.W.1, "Comparative Tests on Various Types of Bars as Reinforcement of Concrete Beams," K. Hajnal-Konyi, 6 p.m.

Institution of Water Engineers

Mon., May 21st.—Institution of Civil Engineers, Great George Street, Westminster, S.W.1, "The Genissiat Dam and Hydro-Electric Plant," M. P. de Lattre, 5.30 p.m.

Old Centralians

Thurs., May 17th.—Chez Auguste Restaurant, Frith Street, London, W.1, "Geological Exploration in Britain," G. M. Lees, 12.55 p.m.

Society of Engineers

Fri., May 25th.—17, Victoria Street, London, S.W.1, "Colloidal Mixes and Their Applications," C. L. Laing, 6.30 p.m.

Society of Instrument Technology

Tues., May 29th.—Manson House, Portland Place, London, W.1, Annual General Meeting, 7 p.m.

Codes of Practice

The Council for Codes of Practice for Buildings—onstruction and Engineering Services, is under the egis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

Code 413: "Design and Construction of Ducts for Services." The Council for Codes of Practice for Buildings has now issued this code in final form. This Code was previously issued, as a draft for comment, as Code 304.105: "Design and Construction of Pipe Ducts," but it was decided to enlarge the scope to include ducts for all services besides pipes. The code was revised before publication by a committee convened by the Institution of Mechanical Engineers, on behalf of the Council. The code deals with the design and construction of all forms of ducts for the accommodation of pipes, cables, &c., within and adjacent to buildings. With regard to preliminary exchange of information, the importance of early and thorough co-operation between the various parties concerned is stressed—especially with a view to the possible future extension or alteration of the services required. Notes are included on the preparation of a time schedule and a list gives the relevant British Standards appertaining to the materials required in the construction of ducts. The types and arrangement of ducts, chases, trenches and subways to suit the various requirements of the services they carry are described in considerable detail. Guidance is given on the methods of and materials for construction; and details are set out regarding the access arrangements, suppression of noise, avoidance of transmission of heat and, in particular, the precautions necessary to ensure that the system of ducts does not increase the fire risk in a building. The code concludes with recommendations on inspection and general maintenance of the completed ducts and there are some illustrations showing the construction of typical vertical and horizontal ducts, crawlways and subways. The code carries the usual warning that, during the present abnormal conditions, it may not be possible to carry out all the recommendations. Price 3s., post free.

Launches and Trial Trips

MARANON, river gunboat; built by John I. Thornycroft and Co., Ltd., for the Peruvian Government; length 154ft 9in, breadth 32ft, 350 tons displacement on 4ft draught; two British Polar diesel engines, each of 400 b.h.p. at 350 r.p.m., speed 12 knots. Launch, April 23rd.

BRITISH SEAFARER, motor tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the British Tanker Company, Ltd.; length overall 547ft, breadth moulded 69ft 6in, depth moulded 37ft 6in, deadweight 16,000 tons; twenty-seven cargo oil tanks, two pump rooms, four duplex compound pumps; Hawthorn-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m., two auxiliary cylindrical boilers. Trial, April 25th.

DROFN, steam trawler; built by Hall, Russell and Co., Ltd., for the Icelandic Government; length between perpendiculars 183ft 6in., breadth moulded 30ft, depth moulded 16ft; steam fish meal plant, cod liver oil plant; triple-expansion steam engine taking superheated steam from an oil-fired boiler, 1200 i.h.p. Trial, April 26th.

INSTITUTION OF MINING ENGINEERS.—Mr. R. J. Weeks, M.A., has been unanimously elected President of the Institution of Mining Engineers for 1952–53. He will succeed Sir Andrew Bryan at the annual general meeting early in 1952.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

PACKAGING: WOODEN CONTAINERS

No. 1133, Section 8. This, the largest single section of the Packaging Code, covers all types of sawn wood and plywood cases and boxes, casks, barrels and crates; it also includes a section on closures for returnable cases. A chart is included to assist in calculating various details of skids for large framed cases; a chart for sizes of nails to be used is also included. Price 10s. 6d., post free.

METHODS FOR THE ANALYSIS OF IRON AND STEEL

No. 1121: 1951, Parts 19, 20, 21. Part 19 of the standard deals with the absorptiometric determination of up to 0·05 per cent silicon, using the molybdenum blue colour developed from the reduction of silico-molybdate.

Part 20 for the determination of tin is based on the isolation of tin as the sulphide, using molybdenum sulphide as a carrier agent, solution and reduction of the tin to the bivalent condition with metallic aluminium in the presence of an antimony salt and normal titration of the reduced tin with standard iodate.

Part 21 of the standard deals with the determination of aluminium oxide and is based on the separation of insoluble aluminium oxide when the sample is treated with a mixture of methyl alcohol and bromine. The residue is fused with potassium bisulphate, extracted in dilute sulphuric acid, and iron and titanium are separated by precipitation with cupferron. Aluminium is precipitated with 8-hydroxyquinoline and the compound is either weighed or titrated.

Price 1s. each part.

TYPICAL SHIPS' DERRICK RIGS

No. 1700: 1950. This standard is intended as a guide for those concerned with the working of cargo and provides information on the components of ships' cargo lifting tackle. A series of four drawings of different methods of rig of ships' derricks serves to illustrate the correct nomenclature employed and a table, associated with a key diagram, provides the coefficients for estimating rope tensions and a method of calculating these is given in an appendix. Another set of four drawings of typical derrick rigs illustrates the method of estimating resultant loads by means of force diagrams. Extracts from other standards give particulars of shackles, ropes, sheaves, &c., and a table gives the recommended safe working loads for slewing guys. Notes on the care and maintenance of ships' cargo lifting blocks are included and also extracts from the docks regulations. Price 7s. 6d.

PAINT TINS

No. 1262: 1950, Part 2. It is well-known that legislation introduced during the 1939–1945 war limited the sizes of tins that could be used in the United Kingdom for many products. The paint industry found that such limitation had many advantages in practice and is eager not to revert to the pre-war situation in which almost every paint manufacturer used different sizes of small tins. This Standard has been issued at the request of the paint industry, which lays down diameters of round lever lid tins, tapered top tins and flat top tins in sizes between ½ pint and 1 gallon nominal capacity. It will not be possible for packers to use all the sizes listed in this Standard until such time as the Control of Containers and Packaging Orders have been withdrawn, but many of the sizes are not inconsistent with the current Orders and can be used immediately. This is the first British Standard for tins to introduce a new feature in the method of specifying sizes. It lays down diameters and capacities which allow adequate ullage in relation to the nominal capacity. The height of the tins is not specified because the fundamental differences in the designs of lever rings and caps made by different manufacturers result in different depths of closure and the specification of a uniform overall height would give differences in the capacities of the tins. Tapered top tins are at present made in many diameters but, from the paint packers' point of view, it would be advantageous if they could be of the same diameters as the corresponding lever lid tins. A table is therefore included in the Standard, which recommends diameters for tapered top tins, and, while it is recognised that strict compliance with that table may not be possible for some years, it is hoped that manufacturers of paint tins will work towards the full implementation of the Standard in this respect when they are replacing machinery and tools. Price 2s.